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Studies of Geysers and Hot Springs along the Firehole River

Yellowstone National Park, Wyoming

by

GEORGE D. MARLER

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INTRODUCTION

There is a steady demand for more and more information about the geysers of Yellowstone. This booklet was prepared to meet such a demand. It is not for the casual visitor who waits impatiently for Old Faithful to play, then rushes away to tell his friends he has seen Yellowstone. Rather, it is addressed to the visitor with a serious desire to learn about geysers, the person who takes the time to visit the Firehole Basins and is interested in the history, the individual characteristics, and the relationships among the major geysers. The interested visitor and scientist alike will recognize this booklet as a distillation of many years' observations, truly a benchmark in the knowledge of geyser activity.

George D. Marler, the author, knows more about the geysers and hot springs along the Firehole River than any man has ever known. This unqualified statement may cause the reader to raise an eyebrow in this age of scientific hedging, but it is the simple truth.

He was studying the geysers in the early 1930's when E. T. Allen and Arthur L. Day of the Carnegie Institution were preparing their monumental work, HOT SPRINGS OF THE YELLOWSTONE NATIONAL PARK. The sketch of Grand Geyser upon the cover of this booklet was done in the spring of 1934. And Dr. Marler continues his studies today, learning more and more about behavior patterns of the Yellowstone geysers.

Our predictions of the times when geysers will play are based on Dr. Marler's ability to guage when boiling or calm waters will blast into geyser activity. Many of the most interesting facts used at our evening campfire programs and cone talks are also the products of his research.

Take this booklet when you visit the geysers; you will find it increases your appreciation of them tremendously. You may recognize the indicators which foretell a geyser's play, and perhaps you will sense the appeal which leads the scientist to spend his life studying these wonders of nature—geysers.

John M. Good
Chief Naturalist

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Studies of Geysers and Hot Springs along the Firehole River Yellowstone National Park, Wyoming

By
GEORGE D. MARLER

LOWER GEYSER BASIN

The Lower Geyser Basin is the largest thermal area in the Park. Its exact size has not been determined, but it is estimated to be about 18 square miles. This includes Midway Geyser Basin, which topographically is a part of the Lower Basin. For the most part the basin is a relatively flat plane covered with glacial sediments and large expanses of siliceous sinter. The plain is interspersed with numerous meadows and groves of lodgepole pine. It is surrounded by rhyolite ridges, which form steep escarpments in some sections. Bordering the ridges, particularly on the east and north sides, and in places extending into the basin, are numerous glacial moraines. A series of these moraines extends southwest from where Nez Perce Creek enters the basin to Twin Buttes, the largest moraines in the Park. Geological evidence suggests that these moraines mark the sites of pre-glacial hot springs. A rhyolite ridge, with an east and west trend, is located in the middle of the basin. Another rhyolite outcrop is found near and east of Excelsior Geyser. The Firehole River courses through the central part of the basin. A number of small creeks form tributaries; the principal ones being Nez Perce, Sentinel, Fairy, Rabbit and White. All of the drainage of the latter two creeks is hot water.

Groups of hot springs are widely scattered over the entire basin. However, with two exceptions, the principal ones are found on the east side. Numerous mud springs are found near the west side in the Pocket Basin area. While the Lower Basin does not equal the Upper in number of geysers, no other area in the Park equals it in discharge of hot water. Measurements made in 1930 indicated a volume of about 34 second feet, which amounts to about 15,300 gallons per minute.

Fountain Complex

Three important geysers, Fountain, Morning and Clepsydra, dominate the Fountain Complex. Other geysers are Twig, Jet, Spasm, Jelly and Sub. All are connected subterraneously. The complex also includes several unnamed springs. During most of the known history the major portion of the thermal energy has found expression through Fountain, Clepsydra and Jet.

Fountain Geyser

During the horse and buggy era Fountain was the most important geyser in the Lower Basin. This resulted from its nearness to established camps and the frequency of its eruptions. It is situated on and near the center of a wide bench of geyserite. It has a greater mass of sinter about its crater than any other geyser in the complex. The massive shoulder of geyserite which partially girds the crater is widest on the south side. It is about 8 feet broad and 18 inches high. The structure of the sinter presents certain evidence that during a large portion of the life of Fountain there has been frequent, and perhaps at times, near constant ebullition.

The crater has rather square corners and is about 20 x 39 feet. The bowl is from 8 to 10 feet deep, except on the south side where the cavern-like vent enters the crater.

During the quiet phase there is no ebullition. The water is of a deep azure color, making it one of the beautiful pools in the Park. During dormant periods the water cools, permitting yellow algae (primitive plants) to line the crater. The water then is of a lovely emerald hue.

Except for casual and infrequent references, there is an almost complete lack of data on hot-spring activity in the Lower Basin during the first half century following the creation of Yellowstone as a National Park. Earliest records of Fountain's behavior indicate that the eruption intervals varied between about 4 and 6 hours; the eruptions lasting from 30 to 60 minutes. The maximum height was estimated to be about 50 feet. Another early, but later reference states that the eruptions occur at intervals from 2 to 4 hours, lasting for about 10 to 15 minutes: most of the bursts being from 10 to 15 feet high. This seeming contradiction resulted from the fact that Fountain's eruptions are not stereotyped; it can and does erupt on different patterns. This fact has come to light since the 1959 earthquake.

About 1925 Fountain became dormant. There is no further evidence of eruptive activity until 1947. During the long period of dormancy, the water had cooled, permitting brownish, filamentous algae to line the crater. The crater also contained several poles which had been thrown in by thoughtless visitors.

From 1947 until the 1959 earthquake, Fountain was in an

active cycle. While the duration of its eruptions and their character were essentially the same as those described in the 1870's, the pattern of activity was very different. Preceding the rejuvenation of Fountain, a large pool bordering it on the north rejuvenated. The pool was later named Morning Geyser.

Fountain and Morning are connected by a small channel at the surface, but they are also connected subterraneously. This has been demonstrated by an interesting pattern of activity. An eruption of Morning initiated a chain action of the major geysers in the complex. Always, following an eruption of Morning, Clepsydra would have a protracted period of play, which was followed by one or more eruptions of Fountain. While this chain action invariably followed an eruption of Morning, both Clepsydra and Fountain had occasional independent eruptions.

During the 12-year cycle of activity, Fountain erupted about 3 to 6 times each week, with occasional short dormant periods. The average eruption lasted about 45 minutes. There were bursts from 40 to 50 feet, but most of the bursts, which followed one another in rapid sequence, were from 18 to 20 feet high. At the end of the eruption, the level of the water in the crater was down 15 to 18 inches.

Fountain has an interesting indicator when in a major eruption cycle. From 45 to 60 minutes before an eruption, water starts bubbling over the main vent. This bubbling which eventually becomes boiling, increases until the eruption occurs.

The Hebgen Lake earthquake of August 17, 1959, resulted in marked changes in hot-spring activity. The initial shock stimulated hundreds of springs into eruptive activity. Fountain, Morning and Clepsydra were among them. With the first heavy shock Morning and Clepsydra began erupting simultaneously. Fountain soon followed. Concerted eruptions of these geysers had never been witnessed before. Fountain ceased playing the following day and became dormant.

During the winter of 1962-63 Fountain rejuvenated. The pattern of activity was very different from its pre-quake behavior. During the early part of 1963 the eruptions occurred about every 12 minutes, lasting for 4 minutes; the height varied between 10 and 25 feet. As the season progressed the intervals became more irregular and longer, the force of the eruptions greater. Fountain is versatile and can erupt on more than one pattern of activity.

Morning Geyser

This important geyser has been in an eruptive cycle but twice since the Park was established. Structural conditions about the crater are indicative of earlier ones. The earliest recorded cycle was at the close of the century. In reference to this cycle **Haynes Guide** states: "In July 1899 the Fountain Geyser ceased eruptions

MORNING GEYSER — Crater of Fountain Geyser in foreground.

and remained inactive until October, when it resumed its usual displays. In the meantime an immense geyser broke out in the large pool north of Fountain. Its eruptions were of great force, quite irregular, but gave exhibitions equal to Old Faithful, only continuing, at times, fully an hour." (1906, p. 46). No further activity is recorded until the 1946 season, when two eruptions are known to have occurred. In June 1947 this large pool began erupting one to three times each week, and continued this pattern, with occasional variations, until the 1959 earthquake.

Following the 1947 rejuvenation, and until the earthquake, with but two known exceptions, all of the eruptions occurred during the morning hours; most taking place between 9 and 11 o'clock. Because of this unusual habit it was named Morning Geyser.

Another interesting facet, which apparently did not characterize the 1899 cycle, was that when Morning erupted, invariably there were follow-up eruptions of Clepsydra and Fountain. From one to three hours following an eruption of Morning, Clepsydra would go into what was called a "wild phase" eruption, which would last from three to six hours. A few hours following this activity Fountain would erupt.

Morning is one of the most spectacular geysers in the Park. Water overflows steadily from its crater during the quiet phase. As is the case with the majority of geysers which have this type of overflow, there are no premonitory signs of an eruption. The activity starts immediately following a sudden lift in water level, resulting in heavy overflow. Boiling then begins, followed by surging and then explosions.

The eruptions are the fountain type. The independent bursts come in rapid succession. During activity, which lasts from 50 to 60 minutes, not less than 300 separate explosions take place. Most of the bursts are from 20 to 40 feet high, with occasional ones of 100 feet and over. Explosions reaching about 150 feet have been observed. The big bursts of water are very spectacular. Their width is not less than 60 feet. The superheated water suddenly released into the atmosphere results in many separate jets and rockets throughout the erupted mass. There is no diminution in vigor during the entire period of activity. Frequently the biggest bursts are near the end of an eruption. It takes from 6 to 9 hours for the crater to refill following an eruption.

During the recent cycle of activity Morning erupted from one to three times each week. The most intense activity occurred in August and September 1958, when the average interval was about 36 hours. There were a few periods of dormancy, mostly in winter.

The eruption which was stimulated by the earthquake of August 17, 1959, completely altered Morning's pattern of behavior, bringing about eventual dormancy. While the action of Clepsydra and Fountain were continuous throughout all of August 18. Morning would have occasional pauses of 2 to 3 minutes, with the active phase lasting from 40 to 50 minutes. During the 19th and 20th the length of the eruptions was still the same as on the 18th, but the pauses or intervals had increased from 12 to 30 minutes. From then until the 25th there was a gradual shortening of the active phase and an increase in the length of the quiet one. On the 25th, the intervals were from 40 to 60 minutes, the eruptions lasting from 10 to 18 minutes. Then until activity ceased on September 1 the eruptions were brief, lasting from 3 to 5 minutes, with the quiet phase lasting from 60 to 73 minutes. During this concluding stage the bursts of water were greatly enfeebled, being not more than 10 feet high.

The cause of Morning's dormancy apparently was shift of the thermal energy to springs lying near and to the west, particularly Clepsydra. Many springs in this area which had been dormant before the earthquake were stimulated into eruptive activity, which has persisted. The rejuvenation of Fountain in 1963 resulted in a further draft on Morning's energy. Its temperature dropped from 192 to 146 degrees F. Only time will tell if and when Morning might again enter an eruption cycle.

Clepsydra Geyser

The name Clepsydra is derived from a Greek word, meaning water clock. It was named in 1873 from an observed rhythm and regularity in its eruptions, "Like the ancient water-clock of that name, it marks the passage of time by the discharge of water."

It erupts from an elongated cone; 2 feet high and 12 feet long. The shape of the cone results from the fact that when the spring

had its origin water issued from what might have been an earthquake-caused rift. Water now plays from four vents, which are in a line from southeast to northwest. Three of the vents are on the raised structure, while the most westerly one is at its base.

Like many geysers, Clepsydra has more than one type of an eruption. The activity that has characterized it during most of its known history has been a splash-type eruption from the highest vents on the cone. It received its water-clock name from the fact that when this type of an eruption is its pattern of play, water jets 10 to 15 feet high at 3 minute intervals. These eruptions are of long and unknown duration. It is the frequent splashing activity that has increased the height of the middle section of the cone.

The second type eruption is much more forceful and powerful. It has been called a wild phase activity. During this eruption, which lasts from 3 to 6 hours, water plays steadily from all four vents under great pressure. From the central vent water jets 20 to 30 feet high, with occasional jets near 40 feet. The orifice on the west end of the cone is primarily a steam vent. During most eruptions, steam commingled with water, issues under great pressure accompanied by a roar which is deafening to one standing near the geyser. This aspect of the eruption is awesome.

Until Morning rejuvenated, wild phase eruptions of Clepsydra were very infrequent. There are references which indicate such eruptions might have been observed in the 1880's and 1890's. In the 1940's a few were known to have occurred. Following Morning's rejuvenation wild phase eruptions, with no known exceptions, followed eruptions of Morning. Soon after the wild phase eruption, Clepsydra would start the splash-type eruption, which would continue until the next wild phase.

As indicated in the discussions on Fountain and Morning, the 1959 earthquake stimulated Clepsydra into wild phase activity. Without any known cessation this activity continued for three and one-half years. Following the rejuvenation of Fountain in 1963, action of Clepsydra's steam vent, except on infrequent occasions, ceased. The force of the constant activity lessened and there were occasional short pauses in the jetting of all vents.

Known facts suggest it was the unceasing activity of Clepsydra, and rejuvenation of near-by springs, that brought about the dormancy of Fountain and Morning. Fountain's rejuvenation, followed by the lessened activity of Clepsydra, is indicative that some of the thermal energy is shifting back in the direction of Fountain and Morning.

Jet Geyser

Jet erupts through several small vents. These vents are in a line on an elongated cone, which has a striking similarity to Clepsydra's in shape and general alignment. This is additional evidence

that a fracture at one time was formed in the geyserite base on which both cones rest.

Little is known about Jet's activity prior to the 1920's. Since then and until the 1959 earthquake, it was a frequent performer. When not influenced by other geysers it erupted about every 5 minutes, the action lasting for less than a minute. Small jets, some of them 10 to 12 feet high, issued from several small openings along the cone. The eruptions started and ended with great abruptness.

A marked sympathy exists among Jet, Fountain and Morning. During an eruption of Morning, and for several hours afterward, Jet is dormant. As soon as Fountain begins erupting, activity is resumed in Jet. The eruptions during Fountain's activity are more forceful than those occurring at other times.

Jet became dormant following the earthquake. In late 1962 it began having occasional eruptions. This was no doubt a prelude to the rejuvenation of Fountain. In 1963 Jet erupted frequently, but not on its pre-quake pattern. The marked sympathy still exists between it and Fountain.

Spasm Geyser

Spasm is in a bowl-like depression near Clepsydra. It is very erratic in its activity due to marked sympathy which exists between it and other geysers of the Fountain complex. Its eruptions vary greatly in character; some being no more than 3 to 4 feet high, while others reach a height of 25 to 35 feet. Some eruptions have a marked steam phase. At the beginning of major eruptions the ground about the vent pounds and shudders. Some seasons it is active most of the time.

There are several additional small geysers in the Fountain complex. A few feet south of Spasm is one called Jelly in allusion to the jelly-like algae in the overflow channels. Some seasons it is more active than during others; the intervals varying between about 9 and 30 minutes. Jelly's activity is influenced by eruptions of Spasm.

Gentian Pool

This beautiful spring is located in the sinter flat about 550 yards north of the Fountain complex. The crater is 50 x 87 feet and appears to be of abysmal depth. A thin, scalloped ledge of geyserite surrounds the crater. Sinter shelves are characteristic of springs of high temperature and constant level. The only known change in water level resulted from the 1959 earthquake when the level dropped 41 inches. After a few months it again began its steady overflow, but in a slightly different direction due to tilting of the crater.

The water is a gentian-blue in color with an opalescent hue. In coloration the pool is gem-like and resplendently beautiful.

There are a number of interesting geysers located from a few feet to 300 yards west and south of Gentian. Among the named ones are Honey Comb, Deep Blue and Kaleidoscope. The last is cyclic in its activity. When in an active cycle its intervals vary from about 3 to 45 minutes. The eruptions last for 2 minutes and are 25 to 30 feet in height.

Following the 1959 earthquake major eruptions began issuing from a fissure near Gentian. The eruptions were massive, playing to a height of about 100 feet and lasting for 11 minutes; the intervals were about 4 hours. It was named Earthquake Geyser. Cessation of eruptive activity apparently resulted from the development of a steam vent on the same fissure.

White Dome Geyser

White Dome, including the mound on which it rests, rises about 20 feet. The cone itself is 12 feet high. Except for mounds in the Sentinel Creek area, it is much larger than any cone in the Lower Basin. In size and shape it resembles some of the cones in the Upper Basin. Like the cones of many geysers in both the Upper and Lower Basins, White Dome's is situated on an older structure; a structure which was built up by a spring long extinct.

As a geyser, White Dome appears to be in the waning stages of activity, which has been brought about by a slowly constricting pipe or vent. Growing constriction will eventually seal it off from the source of thermal energy. There is abundant evidence that if any alkaline spring functions long enough, internal deposition will ultimately bring about its demise by sealing it in. Despite the size of the cone, the orifice is less than 4 inches in diameter.

It was named in 1871 by the Hayden Survey. When this party was again in the Lower Basin in 1878 Dr. Hayden noted that "It spouts irregularly about 5 or 6 feet, occasionally reaching 10 or 12 feet. There is very little water ejected, steam mingled with spray predominating." (1878, p. 162). Following this observation nearly half a century elapsed before any further reference to this geyser can be found.

Observations made during the past 30 years reveal that White Dome is a rather consistent performer, frequently showing a high degree of regularity. The intervals vary between about 11 and 90 minutes, infrequently longer. There are periods when the intervals consistently are short—15 to 25 minutes—and show little variation; with other periods when the longer intervals are the rule. The cause of this vacillation has not yet been determined.

If the height of the eruption as given by the Hayden Survey is a true picture of that period, White Dome is a more powerful geyser today than then. The heights of the eruptions vary between

20 and 30 feet. During the early part of the eruption the jet consists largely of water; as the activity progresses this changes to "steam mingled with spray". An eruption lasts about 2 minutes.

Great Fountain Geyser

In 1871 the Hayden Survey named this geyser Architectural Fountain, and the following year renamed it Great Fountain. It, like White Dome, is located on the eastern fringe of the Lower Basin. During the early days of Park travel this isolation from the main route of travel between the basins resulted in infrequent visitation—hence the absence of data.

Artemisia in the Upper Basin is the only geyser in the Park that compares with Great Fountain in the beauty of its sinter deposits. The structure resembles a large circular table, in the center of which the crater is located. The circular platform, 150 feet in diameter, rises from 10 to 48 inches above its surroundings. The surface appears relatively flat, but is made up of a diversity of forms of sinter deposits. Near the crater are several basins which are always full of crystal-clear water. They are of exquisite design and configuration. The fantastic shape of the deposits gives an "architectural" appearance. The crater is 13.5 x 19.5 feet and has been plumbed to a depth of 42 feet.

During most of Great Fountain's known history the eruption intervals have varied between about 9 and 17 hours. Until the 1959 earthquake about two eruptions occurred daily. The earthquake disrupted this pattern. For several weeks following the big tremors the intervals were shortened to an average of slightly less than 6 hours. One interval of 3 hours and 10 minutes—the shortest on record—was determined. By 1960 the eruptions were occurring about three times daily, and have continued on this frequency to date.

The water in the crater is superheated, being from one to three degrees above boiling. This results in near constant sizzling where the water touches the sides of the crater. During the quiet phase there is a rhythmic ebb and flow, occurring about every 40 to 45 minutes. The water rises to near the rim of the crater and then drops 8 to 12 inches. When the time of an eruption approaches, water will start flowing from the crater. In recent years the flow will momentarily start one or more times, only to ebb. The overflow before an eruption is continuous and serves as a good indicator, preceding the eruption by about 1 hour. The time of the overflow is variable, ranging between about 50 and 80 minutes. In late autumn and early winter the overflow will continue sometimes for many hours before an eruption. This condition seems to result from a seasonally cooler body of ground water. The state of the water in and about the crater is such that, to one familiar with Great Fountain's habits, the time of an eruption can be predicted with relative accuracy any time during the quiet phase.

During the overflow period, at about 5 minute intervals, boiling momentarily occurs. As the time of the eruption approaches the boiling increases in vigor, becoming surges. One of these surges suddenly becomes voluminous, initiating the eruption. The eruption consists of a series of separate explosions, which in volume and height show wide variation. After 5 to 7 minutes of eruptive activity there is a pause of 8 to 12 minutes, then activity is resumed for about 5 minutes. The eruption lasts about 1 hour, during which there are usually four separate periods of activity.

The biggest bursts generally occur during the first few moments of activity. A huge mass of water is suddenly and dramatically exploded into the air. "The effect is that of a great fountain with a thousand jets whirling and interlacing in every direction." For different eruptions there is wide variation in maximum height; for some eruptions it is scarcely more than 50 feet. During most eruptions one or more bursts will reach about 100 feet. If there is not too much dissipation of energy during the first minute or two of activity, magnificent bursts reaching not less than 200 feet occur on infrequent occasions. These tremendous explosions seem to be more common in late summer than at any other time of the year.

MIDWAY GEYSER BASIN

This basin, as previously indicated, is topographically a part of the Lower Basin. It was no doubt given basin status because dense forests to the north and west separate it from other hot-spring groups in the Lower Basin. At one time Midway was known as Half-way Group or Egeria Springs. Its hot springs extend along the Firehole River for a distance of about a mile, and then for an additional mile along the Rabbit Creek drainage. Springs are numerous along both drainages, but geysers are relatively scarce. Only ten springs are known to be geysers; with the exception of Excelsior, all are small.

Midway possesses two remarkable springs. One, Grand Prismatic, is outstanding for its beauty; the other, Excelsior, is noted for its power as a geyser and great discharge of water. However, there are other lovely springs which include Turquoise and Indigo among the named ones, and several unnamed ones near the head of Rabbit Creek. The second largest spring in the Park is located in the latter area; also a few pools which are brick-red in color.

Excelsior Geyser

This remarkable spring was named Cliff Cauldron in 1878 by the Hayden Survey. The name was suggested from the fact that laminated deposits, which form sheer cliffs 15 feet high on the south side, encircle the crater except in the direction of the river. In 1881 when it entered a cycle of activity, it was renamed Excelsior Geyser by Superintendent P. W. Norris.

The crater is approximately 200 x 330 feet, and is one of the most awesome of any in the Park. Due to its size, and the fact that the temperature is boiling—199 degrees F.—great clouds of steam hover over the crater obscuring the view except on warm, dry days, or when a wind momentarily clears the surface. The water is in a constant state of ebullition. From innumerable places on the shallow shoulders of the crater, gas bubbles can be seen evolving. Because of the great size of the crater, its depth has never been sounded. The water is deep blue, but where it cascades over the embankment into the Firehole River, the channels are brilliantly colored with algal hues of yellows, orange and red.

No other spring in the Park even closely approaches Excelsior in total discharge. Measurements made in 1958 indicate a value of nearly 9 second feet. This amounts to approximately 4050 gallons per minute. A remarkable heating unit would be required to produce boiling water at this rate. One of the interesting facets of the heavy flow is that it is constant. It does not show periodic fluctuation which is characteristic of practically all other springs. Even the 1959 earthquake, which had such marked effects on the flow of most springs, did not in any noticeable way affect the volume of flow from Excelsior. For three days the water was murky and then rapidly cleared.

The first known eruptive activity occurred in 1881. A man named C. H. Wyman was detailed by Superintendent Norris to observe and report on the activity. Wyman spent 11 days, from September 27 through October 7, and observed 63 eruptions. He reported the duration of the eruptions as being from 4 to 15 minutes; the average 6½ minutes; heights were estimated to vary between about 50 and 300 feet, often near 100 feet. There was possibly some exaggeration in maximum height estimates, but an explosion of water from this immense crater was a magnificent spectacle.

The apparent cause of dormancy resulted from gas leakage. The floor of the crater rests in glacial gravels. The explosive eruptions produced many fractures in partially consolidated gravels, resulting in dissipation of the thermal energy. The nature of the crater bears mute evidence that periodically Excelsior has had eruption cycles preceding that of the 1880's. When present internal deposition of siliceous sinter sufficiently seals off the energy leakage, a new cycle of activity will ensue. As a geyser, Excelsior is relatively new. The crater has been formed in the laminated deposits of Grand Prismatic Spring.

Grand Prismatic Spring

Grand Prismatic sits at the top of a wide spreading mound. It is nearly circular in outline, being 370 feet in its greatest diameter. It is unique among the many springs in the Park in that the water overflows the crater in all directions and not through well defined drainage channels. The overflowing water has built up a

Table of Named Hot Springs in the Midway & Lower Geyser Basins Which Have Shown Geyser Activity

	Height	Duration	Interval
Bead Geyser	10-12 ft.	1-1½ min.	20-30 min.
Bellefontaine Geyser	6-8 ft.	2-3 min.	Infrequent
Catfish Geyser	2-3 ft.	2-3 min.	20-30 min.
Celestine Pool	8-10 ft.	Unrecorded	Rare
Cone Geyser	1-2 ft.	10-15 min.	Infrequent
Deep Blue Spring	10-30 ft.	1-2 min.	2-3 hrs.*
Earthquake Geyser	100-125 ft.	8-10 min.	4 hrs. Rare
Excelsior Geyser	50-300 ft.	Unrecorded	Rare
Flood Geyser	10-15 ft.	20-40 min.	2-4 hrs.*
Flood Geyser, West	10-15 ft.	15-20 min.	2-4 hrs.*
Fountain Geyser	10-50 ft.	4-60 min.	10 min. to days*
Fortress Geyser	4-6 ft.	Unrecorded	Unrecorded
Gemini Geyser	6-8 ft.	2-3 min.	3-4 hrs.*
Great Fountain	75-200 ft.	35-60 min.	5-17 hrs.
Gourd Spring	3-4 ft.	1 min.	Rare
Honey Comb Geyser	10-20 ft.	2-3 min.	1-2 hrs.*
Imperial Geyser	50-90 ft.	1-5 hrs.	Rare
Jelly Geyser	1-15 ft.	3 min.	10-12 min.
Jet Geyser	10-15 ft.	Few Seconds	5-60 min.*
Kaleidoscope Geyser	25-35 ft.	1½-2 min.	3-20 min.*
Kaleidoscope Drain	40-50 ft.	2-3 min.	1-2 hrs.*
Kidney Geyser	1-2 ft.	1-2 min.	6-8 min.
Leather Pool	20-30 ft.	1 min.	Rare
Mask Geyser	6-10 ft.	4 min.	3-4 hrs.
Morning Geyser	20-150 ft.	45-60 min.	2-3 weekly*
Morning Mist	3-4 ft.	Unrecorded	Unrecorded
Mound Geyser	5-6 ft.	Unrecorded	Unrecorded
Mud Spring	3-15 ft.	10-15 min.	6-8 hrs.
Opal Pool	10-20 ft.	1 min.	Rare
Pebble Geyser	2-3 ft.	Unrecorded	Unrecorded
Pink Cone	12-17 ft.	1-2 hrs.	8-10 hrs.
Red Spouter	6-8 ft.	Months	Months
Shelf Spring	5-6 ft.	2-3 min.	Rare
Silex Spring	1-3 ft.	5-10 min.	1-4 hrs.*
Snort Geyser	15-20 ft.	Days	Days
Spasm Geyser	3-25 ft.	10-15 min.	Very Irregular
Spray Geyser	15-20 ft.	Steady	Steady
Steady Geyser	6-15 ft.	Steady	Steady
Sub Geyser	3-6 ft.	1 min.	3-5 min.*
Surprise Pool	6 in.-3 ft.	1-2 min.	50-70 min.
Teakettle, Deleted	1-6 ft.	1-2 min.	2-3 hrs.*
Thomp Spring	1-3 ft.	1 min.	1-2 hrs.*
Thud Geyser	12-15 ft.	3-4 min.	3-4 hrs.*
White Dome Geyser	18-30 ft.	1½-2½ min.	15-90 min.
Young Hopeful Geyser	3-4 ft.	Months	Months

*Sometimes inactive for long periods.

series of small steps or terraces. Due to the great size of this spring, the temperature over the vent, or the depth, has never been determined. It discharges about 560 gallons per minute.

Grand Prismatic is not only the largest spring in Yellowstone, it is the most gorgeous. Its remarkable coloration must be seen to be appreciated. In the central part of the crater the water is of a deep indigo blue, shading to lighter blue, then aquamarine as the depth of the huge bowl lessens. Surrounding the blues there is a brilliant, emerald-green ring, which in turn gives way to an equally lustrous yellow ring. This fades into orange and then surrounding the crater on all sides is a brilliant red. The color rings are sharp and well defined. By climbing the bluff on the opposite side of the river on a clear, warm day, during the **morning** hours, the concentric colors can be viewed in all their loveliness. The gorgeous coloration is often mirrored and reflected in pastel shades in the ascending steam clouds.

UPPER GEYSER BASIN

The Upper Geyser Basin is a part of the Firehole River Valley. The area of the basin is about two square miles, being about two miles long, expanding to an average width of about a mile. It narrows on both ends. Biscuit Basin marks the lower extremity of the basin, while Old Faithful stands at the head. It is surrounded by rocky cliffs, which stand out prominently on the west, northwest and east. Biscuit Basin, about 2¼ miles from Old Faithful, and Black Sand Basin, one mile from Old Faithful, are separate divisions within the Upper Basin. The valley is not only drained by the Firehole River, but by Iron Creek and the Little Firehole River which enter the main stream in the Biscuit Basin area. The important geysers are located near the main river, most of them within a distance of about one mile of each other.

In general the floor of the basin is flat. However in the central part small islands of rhyolite protrude above the surface between the Firehole River and Iron Creek. The greater portion of the basin is filled with glacial gravels, in places several hundred feet thick. In the southern section glacial outwash, consisting largely of obsidian sand, covers the floor, but the greater section of the basin is veneered with siliceous sinter deposits from the hot springs.

The Upper Geyser Basin is said to be "the climax of thermal activity in Yellowstone Park. In the number, size, depth and temperature of its springs, in its remarkable superheated pools, and in the power and beauty of its geysers this basin, it is safe to say, surpasses any similar area on the globe; anything comparable to it would of necessity be known." (Allen and Day, 1935, p. 233).

In discussing some of the more prominent and famous springs in the Upper Basin we shall begin in the lower part, starting at Biscuit Basin and progress toward Old Faithful.

Sapphire Pool

The designation pool rather than geyser was initially attached to Sapphire because of the placid state and pool-like appearance it presented during its quiet phase. Since discovery it has been known to be a geyser.

Of the blue Springs that are crystalline clear, Sapphire, previous to the 1959 earthquake, was without doubt the loveliest. During the quiet phase its water scintillated with all the beauty and brilliance of the Oriental sapphire. Its eruptions occurred about every 15 minutes lasting for about 2 minutes. During the eruption a seething mass of water domed up from 3 to 6 feet. During the quiet phase the water would be from 3 to 5 degrees above boiling.

Prior to the earthquake the crater was surrounded by an interesting form of sinter, which had the appearance of biscuits—hence the name Biscuit Basin. Some of the biscuits extended into the drainage channels, but most of them were near the edge of the crater.

Of all the thermal springs that underwent change due to the 1959 earthquake, none was more spectacular in the degree and nature of change than Sapphire. The change from a geyser whose eruptions were scarcely more than 4 feet in height to one of titanic proportions has but one known parallel in the geyser basins in Yellowstone Park.

On the morning following the August 17, 1959, earthquake, Sapphire was in a state of violent boiling. It was jetting muddy water to a height of about 8 feet. All periodic activity had ceased; the boiling was constant. On September 5 the steady surging gave way to violent eruptions, which occurred at about 2 hour intervals.

The eruptions would come suddenly and explosively. Following an eruption the water would ebb as much as 6 feet in the crater. With constant boiling it would steadily rise. Upon reaching the base of the biscuits the water would suddenly well, overflowing the crater. Within seconds an explosion would lift a huge mass of rocketing jets to heights which varied between 100 and 125 feet. Occasionally there were bursts fully 150 feet high.

The eruptions were spectacular, not only due to their height, but from their lateral extension and the tremendous volume of water discharged during the initial burst, which was estimated to weigh about 50 tons. Most of the eruptions were wider than they were high; arching jets would sometimes extend from 100 to 125 feet away from the center of the crater.

Sapphire's voluminous discharge resulted in a tremendous erosion of surrounding formations. Hundreds of tons of siliceous sinter were washed into the Firehole River. Large blocks of eroded sinter were strewn about the crater and extended in the drainage channels for several hundred feet.

The destruction of surficial geyserite was no greater than that affected within the visible crater. Most of the biscuits that circled the crater have been undermined and washed away. The greatest destruction to the crater has occurred on the west side where there is considerable enlargement.

Since Sapphire began its major eruptions on September 5, 1959, it has had a few short periods of dormancy. During dormant cycles the crater fills and there is steady overflow. From eruption cycle to eruption cycle, as well as during many of these cycles, the character of Sapphire's eruptions has undergone considerable variation. The resumption of activity has always been characterized by larger eruptions than in the later stages of the cycle.

As time has gone on there has been a gradual shortening of the length of the interval, with a more enfeebled type of activity. In general the longer the interval the bigger the eruption. During the past two years none of the eruptions has exceeded 75 feet in height; the length of the interval has varied from about 10 to 30 minutes. The average height of the eruptions is about 20 feet.

The decline in the power of Sapphire's eruptions has apparently resulted from alterations in underground plumbing rather than any decline in thermal energy. The explosive eruptions not only sheared off sections of the crater's walls, but discharged rock fragments indicate that destruction extended to depth. It is problematical whether Sapphire will ever again become the beautiful pool it was before the earthquake. Its water is still slightly murky.

There are many other interesting springs in Biscuit Basin, among which are Jewel Geyser, Mustard and Avoca springs. Both Avoca and the Mustard Springs were turned into geysers as a result of the earthquake. Jewel is about the only geyser in Biscuit Basin that is now erupting in an essentially pre-quake status. It is a frequent performer, erupting about every 5 to 8 minutes, to a height of about 20 feet.

Artemisia Geyser

This geyser was named Restless in 1883 by the Hayden Survey, later to be called Artemisia, apparently due to unawareness of earlier naming.

Artemisia is one of the largest springs in the Upper Basin. It has a diameter of about 50 feet and is 45 feet deep to where the tube turns. There is a steady overflow from the crater during the quiet phase. During this stage the water is of a deep blue color, and when unruffled by wind it is one of the loveliest pools in the Park.

The sinter surrounding the crater of Artemisia represents some of the finest ornamentation in the Park. It consists of masses of cauliflower-like beads and spines, forming islands in the shallow

water. Near the bowl there are many collecting basins whose borders are delicately fringed with nodules which have a metallic luster.

The first indication of an eruption is a sudden rise in water level, resulting in a much heavier overflow. The temperature also jumps from about 191° to 202° F. With the rise in water level, feeble ebullition begins, which is soon followed by boiling and surging. For the first few moments the surging becomes more violent, with separate tongues of water rising above the general mass. Some of the jets reach a height of about 35 feet. The eruption lasts about 13 to 15 minutes, though longer duration has been recorded.

Following the eruption the water sinks about 4 feet below the rim of the crater. There is a gradual rise until the time of overflow which begins about 4 hours following the eruption.

Since first observed Artemisia has not shown much variation in its eruptive pattern. The eruptions have occurred about once daily. However, for a period of several months following the 1959 earthquake, it was stimulated into more frequent activity.

Atomizer Geyser

On the same sinter shoulder with Artemisia two small cones are situated about 150 feet to the west. Both cones form Atomizer Geyser. Some seasons it is more active than during others. It has an interesting eruptive pattern. There are several preliminary eruptions before the main one begins. The preliminary activity occurs about every hour and a half, lasting for less than a minute. The height is about 30 feet. These eruptions are precursors to the main activity which lasts about 10 minutes. In the main eruption the steam begins to manifest itself after less than a minute of steady water ejection. Because the aperture of the cone is only about 4 inches the eruption in the steam phase is suggestive of spray from an atomizer, hence the name. The east cone emits steam only at the time of the main eruption.

Below Artemisia and Atomizer along the river are numerous springs, some of which are geysers. Following the earthquake there was marked increase in activity of most springs. A large earthquake-caused crack in the geyserite on the bank of the river produced a powerful fumarole, which exploded during the 1962-63 winter forming a crater and a new hot spring.

Fan and Mortar

These geysers erupt simultaneously. They are located on the bank of the Firehole near Morning Glory Pool. The amount of erosion their eruptions (especially that of Fan) have affected in an older geyserite is indicative of a great amount of activity over

a relatively long period. However, since the Park was discovered their eruptions have been infrequent most seasons, especially in recent time. There is evidence that lessened activity might be due in part to vandalism.

Two large mortar-like cones mark the site of the Mortar. Fan erupts from several openings along a rift. This rift may have been caused by a major earthquake a few hundred years ago. The issuing water gives a fan-like aspect to the eruption.

At the first signs of an impending eruption water starts jetting 6 to 8 feet high from two of Fan's vents near the river. After a few moments of this preliminary activity there is a sudden effusion of water along the rift, with simultaneous lifting of water in the craters of Mortar. The eruption begins rather explosively. Water shoots into the air from not less than eleven openings. The opening on Fan farthest from the river shoots water out at an angle to a height of not less than 125 feet. The water from the rest of the crack plays mostly vertically.

Mortar's crater nearest the river has very violent activity. For the first moment or two water plays to a height of about 60 feet, but it rapidly enters a steam phase which is most impressive. The ejected steam is released under great pressure, accompanied by loud roaring. During the entire eruption, which lasts from 10 to 13 minutes, the noise of both geysers is quite marked. To see an eruption of Fan and Mortar is to view some of the most spectacular geyser activity in the Park. The infernal region would seem to have broken loose in full fury.

Morning Glory Pool

Morning Glory is located about 150 feet north of the Fan Complex. Despite the fact there are larger, deeper and more colorful springs, Morning Glory has become the most famous. This is largely due to the great amount of publicity it has received since the earliest days of Park visitation. Every season more people visit Morning Glory than any other thermal spring in the Park except Old Faithful.

Heavy visitor impact has resulted in irreparable damage. A delicate scalloped border which at one time fringed the pool has been removed by souvenir hunters. The crater has served as a receptacle for untold quantities of extraneous matter. That Morning Glory is still the beautiful pool it is attests to its remarkable toleration to date.

The crater is 23 x 26.6 feet; it has been plumbed to a depth of 27.5 feet. The shape of the bowl resembles the corolla of a morning glory; this, coupled with a morning-glory blue color, is responsible for the name.

The temperature of the water has ranged between about 158°

and 176°F. During particular seasons it is fairly constant. At times the temperature will lower sufficiently to permit the upper reaches of the bowl to become lined with yellow algae. This affects the blue coloration. On rare occasions Morning Glory has erupted, putting it in that unique group of springs known as geysers.

Riverside Geyser

The Riverside is about 450 feet upstream from the Fan and Mortar. It was named in 1871 by the Hayden party. Little was known about it during the first few decades of the Park's history.

Riverside's mound rises abruptly from the water's edge, on a meander of the Firehole River. Its mass of sinter is situated within an older, badly eroded thermal deposit. Riverside is obviously a successor to a spring of much earlier date.

RIVERSIDE GEYSER—Erupts with marked regularity. Intervals vary between 6 and 8 hours.

The general configuration of Riverside's mound, when viewed from the opposite side of the river, is that of a draped, low-backed chair. When viewed from upstream it looks more like a sofa than a chair. The seat, the section from which the eruption issues, appears cylindrical in form. The orifice is somewhat ovate in shape. At the surface it is 45 x 55 inches and at a depth of 28 inches constricts to 20 x 24 inches. Two additional vents puncture the platform. The smaller, which is nearest the embankment, serves as an indicator to an eruption. Above Riverside's vent (on the back of the chair) there is a large opening, which to the uninitiated looks like the main crater from which the geyser should erupt.

Available records make it reasonably certain that since Riverside's discovery there has been little change in its behavior. What

variation there has been resulted from occasional changes in the eruption interval. Height and duration of the eruptions are essentially the same as in 1871.

Of the major geysers Riverside is perhaps the most regular in the Park. It erupts much less frequently than Old Faithful, but its variation from the average period is less. In recent years Riverside has erupted at approximately 7 hour intervals. The known variations are from about 5½ to 9 hours. Not only does it erupt with a high degree of regularity, but the rate of rise of water in its crater following an eruption, and the time of overflow, serve as very good indicators as to the time of an active period. About two hours after an eruption water can be seen in the bottom of the crater, which is about 80 inches deep. The rise of the water in the well is steady. To one familiar with the rate of rise, relative accuracy in predicting the time of overflow is possible. The time of the overflow preceding an eruption is variable, but most seasons it is near two hours. It has been known to fluctuate between 90 and 180 minutes.

Usually 40 to 50 minutes preceding an eruption water will splash from the upper crater. This is generally followed at indefinite intervals, by succeeding splashes. On occasions splashing will not take place until immediately preceding the eruption, when a few heavy surges seem to trigger activity.

The small vent near the embankment usually starts erupting 30 to 40 minutes ahead of Riverside. However, this time is variable. At times it will precede Riverside by but a few minutes. At times both Riverside and the vent have been observed to start erupting simultaneously.

At the time of one of the heavy surges in the upper crater there is a sudden surge in the lower one, which is immediately followed by arching of the water column, jetting the water to a height of about 75 feet. The angle of the column is about 20 degrees from the vertical, resulting in the falling water spanning a considerable portion of the river.

The water plays to nearly maximum height for about 5 minutes. From then until the end of water ejection, which in total time is about 20 minutes, the water column slowly subsides in height. A weak steam phase follows the water phase for an additional 5 to 8 minutes.

When it comes to setting, Riverside is one of the most fortunate among geysers. Its position on the very edge of the Firehole River, with the column of water arching over the stream, make it the photographer's delight. With proper time of day, and position with reference to sun and wind, beautiful spectral colors in the falling droplets add to the loveliness of the scene. None except one who is immune to manifestations of beauty in nature can remain unmoved when Riverside, under proper atmospheric condition,

rises into the sunshine. Not only is it a "thing of beauty", it is Yellowstone's only known musical geyser; it plays "Over the Waves".

Grotto Geyser Complex

One of the most striking things about the Grotto is the unusual shape of its mound. "This interesting geyser received its name in 1870 from the peculiar shape of the main or larger crater, which is hollowed into fantastic arches, beneath which are grotto-like cavities that act as lateral orifices for the escape of the water during an eruption." (Hayden, 1878, p. 191).

The main crater of Grotto is about 12.5 feet deep. The mass of geyserite forming the structure rises about 8 feet high. It is arch-shaped, showing two main caverns when viewed from the west side. A peculiar pillar of geyserite, club-shaped, rises midway between the arches. This sinter pillar, as well as the rest of the unusual configuration of Grotto, has resulted from tree sections serving as nuclei, about which siliceous sinter has been deposited. Between the hot-spring activity which built up the geyserite platform on which Grotto rests, and the beginning of Grotto as a geyser, there was a long period of dormancy, resulting in trees growing where Grotto is located. Water from Grotto is eording channels into the older sinter.

A symmetrically-shaped cone on the north side of Grotto is called Rocket Geyser. It is 4 feet high; 14 feet in diameter at the top; 19 feet at the bottom. When the Grotto was named by the Washburn Party in 1870, Rocket had no separate designation, but was considered a part of the Grotto. Both erupt simultaneously.

In addition to Rocket, other nearby springs show a sympathetic response to Grotto's eruptions, indicating subterraneous connections. Four of these springs have names: Spa, Surprise and South Surprise Geysers and Grotto's Indicator.

Surprise Geyser, also known as Grotto Fountain, frequently serves as an indicator to an eruption of Grotto. In recent years Surprise has begun erupting anywhere from 2 to 10 minutes ahead of Grotto. It never erupts independently of Grotto. It is an interesting geyser in its own right, playing to a height of about 40 feet for not less than 17 minutes; sometimes much longer. While not a major geyser it is one of the bigger geysers in the Upper Basin. Physical conditions about the crater, as well as its known history, reveal there have been dormant periods, some of them long. Like Grotto, it is eroding into an older sinter.

South Surprise is about 20 feet south of its namesake. Both geysers erupt in concert. Sometimes South Surprise will get the jump on its bigger neighbor, stopping activity in the latter. When this happens, it is 10 or more minutes before Grotto starts erupting.

Spa Geyser is located about 50 feet north of Surprise. The

crater is funnel-shaped, about 30 feet in diameter and 18 feet deep. During an eruption of Grotto the water rises in Spa with resultant overflow and boiling. Sometimes the overflow will last for several hours. On infrequent occasions the boiling is punctuated by explosions which jet the water 30 to 40 feet high. Occasionally, Spa will overflow preceding an eruption of Grotto. When this occurs Grotto's activity is greatly delayed.

There is never any boiling in Grotto's Indicator. The level of the water in the crater fluctuates. Its height reveals the degree of pressure built up in Grotto. When the crater is nearly full, an eruption of Grotto is imminent.

The quiet and active phases of Grotto are about equal in length. It is in eruption fully half of the time. The duration of the eruption, as well as the quiet phase, varies greatly at times. The duration, as well as the interval, might be as short as 45 minutes. On the other extreme it has been known to erupt for 36 hours. During the majority of seasons most of the eruptions last from 6 to 10 hours. The duration of the eruption determines the length of the interval.

In performance the Grotto must be classed as a minor geyser. When its eruptions come in immediate sequence to those of Surprise, the initial burst will jet up from 30 to 40 feet. For the remainder of the eruption the water splashes from the chimney-like openings to a height of from 10 to 15 feet. The initial bursts of Grotto are always higher than succeeding ones.

Rocket erupts in concert with the Grotto, their activity being of the same duration. During the eruption water is continuously splashing and surging. During many of Grotto's eruptions there will be momentary pauses when Rocket will make a notable display, rocketing a massive jet about 30 or 40 feet high. Sometimes major activity of Rocket will last 3 to 5 minutes.

During an eruption the Grotto discharges about 470 gallons per minute. In a single day this amounts to about 676,800 gallons. This exceeds Old Faithful's total daily discharge, which is about 242,000 gallons. Where the flowing water of the eruptions cascades down the embankment to the Firehole, deep channels have been cut in a geyserite which was deposited by a hot spring which antedates the Grotto.

Giant Geyser Complex

Giant Geyser, along with a number of important geysers in the Upper Basin, is located on the bank of the Firehole River. These settings are coincidental. The Firehole does not serve as a source of water. Locations are due to topographical conditions which existed when the river was diverted from the south side of the basin to its present course.

Upon the sinter platform where Giant is situated there are not less than 40 springs, most of them small. In addition to Giant four others have names: Bijou, Catfish, Mastiff and Turtle Geysers. Many of the small springs are geysers. The platform upon which these springs are located was deposited by a hot spring or springs which predate the present course of the river. The horizontal sheets of geyserite composing the old deposits have been badly eroded by the frost and tremendous hydraulic action when Giant is in an eruption. On the river side the sheets have been deeply incised by the abrading stream. The river now separates Giant from Purple Pools, which are connected underground with Giant.

Giant Geyser

The crater of Giant is at once an object of interest. It has aptly been compared to a broken horn. Others have thought the resemblance was more akin to the stump of a hollow tree. The cone rises 10 feet above the platform. The diameter at the base is about 25 feet, which narrows to 8 feet at the top. It is 27.5 feet deep. At one time the cone must have been quite symmetrical, as is present day Beehive's. During the building of the cone the constricting orifice apparently became so nozzled that the tremendous pressure generated by eruptive activity broke away a large section, further adding to the "broken horn" appearance. This rupture antedates discovery.

Due to a lack of systematic observation of all geysers during the first half century following discovery, there is a paucity of information about most of them during this period. Scanty records indicate that Giant has been a geyser of extreme irregularity. Its history is marked by long dormant periods followed by functional

GIANT GEYSER—When in an active cycle erupts every 2 to 14 days.

periods. Since 1920 records are sufficiently complete to indicate that the dormant cycles were of about four years duration; the functional cycles usually less. During an active cycle the intervals show a wide variation of about 2 days to 3 months, the average being about 10 days.

The last functional cycle of the Giant was the longest on record. It began in September 1950 and ended in October 1955. The cycle was not only long, but Giant erupted with unprecedented frequency. During these five years there is a record of more eruptive activity than is recorded for all of its previous known history. It was especially active from early 1952 through 1954, the average eruption interval being about 60 hours.

During the quiet phase, in both the active and dormant cycles, water frequently splashes above the rim of the crater. The splashing is more frequent and volumnious during the active cycles.

The principal cause of Giant's great irregularity—its dormant and functional cycles—was discovered during 1952. Observations made by the author revealed that Giant's subterraneous water tentacles reached far afield, entwining with those of the Grotto Group. These observations revealed that a marked sympathy in functional relationship exists between the two groups; that when the Giant is in an active cycle near dormancy exists in the Grotto Group, and vice versa. (See 1952 **Nature Notes**, No. 6, p. 67).

With the possible exception of Excelsior and Steamboat, Giant has the distinction of being the mightiest geyser in Yellowstone. The name connotes a geyser of first magnitude. The Washburn Party witnessed an eruption at the time of the memorable visit in 1870. To them it was the acme of display. They named it Giant, more in allusion to the "vast body of water" it discharged than to its towering height.

Not until May 1951 was it determined that when Giant is in an eruption cycle it has hot periods. An eruption occurs **only** at the time of one of these hot periods. They take place at about hourly intervals, and last from 4 to 10 minutes, 5 minutes being about average.

At the time of the hot periods Giant and Mastiff show a sudden rise in water level, as well as in temperature. The water in both boils violently. Simultaneously with the sudden rise in Giant and Mastiff the activity of Catfish and Bijou ceases. Within about one minute following the start of a hot period one or more small vents in front of Giant begin jetting water. The termination of the hot period, unless Giant erupts, comes with cessation of play from the small vents and a sudden surge of activity in Bijou and Catfish, particularly Bijou. Sometimes Turtle will erupt about 20 feet high at the time of a hot period. Occasionally Mastiff and Catfish will have major eruptions preceding and for the first few

moments of Giant's activity. Mastiff has been observed to erupt over 100 feet high.

An eruption of Giant comes near the termination of a hot period. The already splashing water starts surging in mass from 10 to 20 feet high and then explosively blasts skyward. Maximum height is attained during the first few big surges of the eruption. If it is to be seen at maximum height it must be observed during the first few moments of the eruption. The water column then slowly subsides; the average eruption lasting about 105 minutes. The height of the eruption is quite variable, being anywhere from 150 to over 200 feet. The discharge of an eruption varies between about 750,000 and 1,000,000 gallons.

Giant is a sublime spectacle to witness. The superheated water suddenly expands upon release from its narrow prison, and instead of the water column being about 3 feet wide (the size of the orifice), it is fully 20 feet in diameter. During the eruption the water is continually surging. Being a cone geyser there is no cessation of activity until the end of the eruption.

As a result of the 1959 earthquake there was a further shift of the thermal energy away from the Giant complex to the Grotto Group. This has resulted in a break in rhythm of the exchange of function between the two groups. No observed precedent exists for this sudden alteration in functional relationship. Hence there is no basis for speculation as to how long it will be before Giant again enters an eruptive cycle.

Oblong Geyser

Oblong lies 460 feet south of Giant. Its name is derived from the shape of its crater. In describing it Dr. Hayden stated: "It is an oblong pool 50 feet in length by 31 feet wide nearest the river, and 21 feet across the opposite end. At the bottom are two large cavern-like bowls that are of great depth and over which the water appears of a deep greenish-blue tint. The ridge, or platform, separating the two bowls is 7 feet below the surface of the water." (1878, p. 198).

When the crater of Oblong is empty following an eruption the elaborately ornamented swells of geyserite which form the upper part of the crater can be seen to best advantage. These globular-sinter masses are the most unusual found in the crater of any geyser. They are numerous and symmetrical. The crater is surrounded by many small collecting basins, all of which are beautifully ornamented, as if they had been sculptured.

While Oblong cannot be considered a major geyser from the standpoint of height, its great volume of discharge, plus its imposing crater, signal it as an object of interest. One of its interesting characteristics is its cyclic overflow during the quiet phase. During this stage the water in the large bowl stands about an inch

below the rim of the crater. About every 15 to 20 minutes the water rises with resultant overflow which lasts a few minutes. Collapse of steam bubbles below the surface, resulting in slight cooling, apparently accounts for the ebb. However, when sufficient temperature is generated one of the overflow periods results in an eruption. The water begins boiling with increasing vigor and is soon surging in dome-like masses. The height of the eruption is between 20 and 25 feet and lasts about 7 minutes. Due to the fact that the great flood of water from Oblong almost immediately cascades into the Firehole River, the volume of discharge has never been determined.

Oblong has been a consistent performer over the years, but it has shown rather wide variation in intervals, which have varied between about 2 and 10 hours. During the majority of seasons the eruption intervals are about 6 to 8 hours.

Daisy Complex

This interesting group of springs, located about 1000 feet west of Giant, consists almost wholly of geysers. Two of them, Daisy and Splendid, are among the most noteworthy in the Upper Basin. Other named springs of importance are Brilliant and Bonita Pools (both geysers), Comet Geyser and Daisy's Thief.

All springs in this group are connected subterraneously. This, coupled with the fact that periodically the focus of the thermal energy will shift from one geyser to another, has resulted in great irregularity for all. Due to their close interfunctional relationships it is impossible to discuss any of the main springs in the Daisy Group without reference to the others. Every spring is so sensitive to even small loss of energy through shift to a neighboring spring as to require a description of most springs in order to explain the behavior of any. For detailed information the reader is referred to "Facts About Daisy Geyser", found in Yellowstone Geyser Observations and References, Vol. I, Yellowstone National Park Reference Library.

Daisy Geyser

While not as large as nearby Splendid, Daisy, due to its long record of activity, is the dominant geyser in the complex. It was named Comet Geyser in 1878 by Dr. F. V. Hayden of the U. S. Geological and Geographical Survey. However, due to later confusion as to proper identification of springs in this group, the name Comet was given to a geyser originally named Spray and the less appropriate name, Daisy, was given to Dr. Hayden's Comet.

Scanty records indicate that during the first three decades of the Park's history Daisy erupted with great irregularity. At times long dormant periods occurred. This erratic behavior was due to frequent eruptive activity of Splendid Geyser. During this

early period Daisy and Splendid would at times erupt simultaneously, affording a sublime spectacle. This concerted activity has not been observed since the 1880's.

Near the turn of the century Splendid became dormant. From then until 1951 Daisy became one of the most frequent and regular of the bigger geysers in the Upper Basin. Its frequency was only surpassed by Old Faithful. One interesting aspect of Daisy's frequency is that the length of the quiet phase shows a marked and somewhat steady increase since the earliest reports, which stated that "Daisy plays about every hour". By 1951, when Splendid rejuvenated, Daisy's intervals were averaging about 2 hours. This decline in activity was due wholly to local conditions and does not reflect a general decline in thermal energy.

The length of Daisy's intervals has been affected not only by occasional shifting of the focus of the thermal energy to subterraneously connected springs, but strong winds also have a retarding effect. The delayed eruptions resulting from strong winds are not caused by surface cooling, but by a slight increase in discharge due to wave action produced by the wind. When the thermal energy in the group finds its major expression in Daisy there is a nicely balanced condition so far as gains and losses in energy are concerned. A slightly increased rate of discharge, as affected by a wind, dissipates energy, thereby delaying the eruption. The amount of delay varies with the wind. Only one other geyser, the Morning, is known to be sensitive to winds.

When in an active cycle Daisy is one of very few geysers whose eruption time is predictable by conditions which exist during the quiet phase. From the moment of an eruption until a succeeding one there is a steady and progressive change in water level in the crater and in the degree of boiling. To one familiar with the changes in all stages there are ample data for predicting the time of an eruption.

The eruption starts when the churning water in the bowl reaches a degree of ebullition that the large globular masses begin to break into incipient jets. These jets rapidly increase in forcefulness. From the time of the initial burst of an eruption it takes from 45 to 60 seconds for the steadily growing column to attain maximum height. This height, about 75 feet, is maintained for about 45 seconds and is characterized by a series of rapid, rocket-like jets. The column then begins to descend. The duration of the eruption varies between 2½ and 3½ minutes. The water is expelled at an angle, which is about 30 degrees from the vertical, giving it a fancied resemblance to a comet, hence its original name.

Daisy is quite conservative with its water. During the entire period of an eruption water in volume flows back into the crater from the large collecting basin. It has been demonstrated that were it not for the inflowing air-chilled water the eruption would last much longer. It seems to be smothered by the stream of returning water.

Whenever Daisy erupts the pronounced sympathy between it and several other springs is made very evident. Daisy's draft of water from these springs, as indicated by lowering water levels, progresses steadily as long as the eruption lasts. Due to the size of their craters the drop in water level is most evident in Bonita and Brilliant Pools and Splendid Geyser. The water in all craters refills simultaneously with Daisy.

Following the rejuvenation of Splendid in 1951, Daisy's occasional eccentricities became much more pronounced, due to a number of factors. Except for short periods, it was largely dormant during 1952 due to frequent activity of Splendid. From then until the 1959 earthquake the intervals varied between about 2 and 3 hours, except during brief periods of eruptive activity of Splendid, which brought about dormancy of Daisy.

No group of springs underwent greater changes as a result of the 1959 earthquake than did the Daisy complex. The morning following the quake the water was down about a foot in the craters of all springs. Many were boiling violently. The thermal energy which previously had been shifting back and forth between Daisy, Splendid and Brilliant Pool had shifted to the east in the direction of Daisy; also new springs and fumaroles had developed on the east side.

The shift of the thermal energy in the direction of Daisy resulted in its erupting with marked frequency. Prior to the earthquake the average interval was 138 minutes; for the following 6 months it was 60 minutes, some of the intervals being less than 30 minutes. This condition continued until February 1960 when the energy shifted farther to the east, to Bonita Pool, which began erupting and overflowing. From the time of this energy shift Daisy began erupting less frequently. By 1961 it became dormant. Until the flow from Bonita ceases, or lessens, Daisy and Splendid will remain inactive.

Factors other than the 1959 earthquake in part are responsible for current lack of major geyser activity in the Daisy complex.

Splendid Geyser

So far as underground connections are concerned, all of the data given on Daisy are applicable to Splendid. The pronounced sympathy shown by all springs in this complex to change in activity of any other spring, indicates the connections are quite open and direct.

Splendid is located 120 feet west of Daisy. Except for a bridge of sinter between two openings, the main crater is practically level with surrounding formations. The crater is 22 x 25 feet and is 16.5 feet deep. Until the 1959 earthquake water stood near the

top of the bowl, but since then the level has been from 6 to 15 inches below the rim.

Splendid was named in 1880 by Superintendent P. W. Norris. Before this date it had become a geyser of much interest. In reference to it an early observer commented: "It is (this season) next to Old Faithful in point of regularity, operating at intervals of about 3 hours. Sometimes not more than one and one-half hours intervened between eruptions. . . There is a smaller geyser east of it [Daisy], which throws an oblique stream; this and Splendid often act together, which enhances the beauty of the spectacle. The Splendid is estimated to throw about 200 feet high." (Wylie, 1882, p. 39).

Sometime near the turn of the century Splendid became dormant. Following this dormancy Daisy became very active, and was one of the most regular and frequent of the bigger geysers in the Park. Splendid did not again enter an eruption cycle until 1951.

Premonitory symptoms of the shifting of the thermal energy back to Splendid after Daisy's long activity manifested themselves several weeks in advance of the rejuvenation. One or more times each week the water would start flowing from the crater, the flow lasting many hours. As long as the overflow lasted Daisy was dormant. Frequently during Splendid's overflow periods water would rocket up from 10 to 30 feet, suggesting the initial throes of an eruption. On July 10, 1951, it again displayed the power and beauty which had engendered great enthusiasm on the part of early viewers.

During an eruption phase there are usually a series of eruptions. The duration of the initial one seems to govern the number of succeeding ones. As many as 4 eruptions, the intervals varying from about 1 to 3 hours, have been observed to follow the first one. Then it would usually be from 2 to 5 days before it would again enter an eruption phase. This behavior corresponds very closely to its manner of functioning during its early history.

From July 1951 through all of 1952 Splendid was very active. Daisy seldom erupted. From 1953 until the 1959 earthquake Splendid would enter an eruption phase once or twice per month, being more active in winter than in summer. Since the 1959 earthquake, due to conditions described in the discussion on Daisy, Splendid has been dormant.

The names that have been given to many of the geysers are adjectives. An eruption of Splendid is truly a "splendid" spectacle. When an eruption is imminent water from the overflowing crater is repeatedly domed up in ever ascending masses. One of these surges suddenly becomes voluminous, with the water shooting skyward. During the first moment of the eruption there is a tremendous deluge, issuing in growing force as if this were the only instant for its escape from the cavernous imprisonment below.

Maximum height is attained within the first minute of play. The duration varies from about 2 to 10 minutes. The water column is near its zenith for the greater portion of the eruption. The height varies between about 100 and 165 feet. An eruption which lasts 8 minutes or more discharges about 40,000 gallons of water.

The history of Splendid indicates that eruptive activity has characterized it only periodically; that the cycles of inactivity have been of much longer duration than the active ones. This picture finds equal confirmation in the structural condition about the crater. The nature of the drainage channels leading away from the craters of Splendid and Daisy presents certain evidence that Daisy has been active for much longer periods than has Splendid. Neither geyser would appear to be as old as Riverside, Grotto, Giant, Castle, Beehive and some others.

The recent cycle of activity of Splendid has resulted in marked erosion and general deflation of the relatively flat expanse of weathered sinter which surrounds the crater. The amount of this deflation, which is largely in an older sinter sheet, makes it unlikely that many eruptive cycles, such as the recent one, could be a part of Splendid's overall picture. To the south where the water of the eruptions has scoured into an older geyserite, buried, silicified tree sections have been exposed.

Cliff Geyser

This geyser was named Cliff because of the cliff-like wall of geyserite which forms the side of the crater next to the creek. It is located on the west bank of Iron Creek 500 feet northeast of Emerald Pool. The crater appears circular and is from 1 to 6 feet deep. Except for a few hours following an eruption the bowl is full of water and overflowing. The water is always near or slightly above boiling in temperature.

Cliff is the largest geyser in Black Sand Basin, that erupts with any degree of frequency. However, it is cyclic and occasionally there will be several weeks when it is dormant. The cause of its dormant periods has not been determined. When in an active cycle there are usually one or two eruptions each day. At times as many as three and four eruptions will occur in a 24-hour period.

An eruption of Cliff is interesting to observe, especially during the first hour of activity. The eruption consists of a series of rapid jets which explode through the water-filled bowl. The jets result from steam explosions at depth. In being projected through the water the spouts are accompanied by marked and loud detonations which are an interesting facet of the eruption.

An eruption lasts for about 3 hours. The forcefulness of the activity gradually subsides as the eruption progresses. There is also a gradual lowering of water in the crater, which is empty by

the end of the eruption. During the first hour many of the water spouts go up 30 to 40 feet.

Emerald Pool

Emerald Pool is located in the Black Sand Basin, which is in the southwestern part of the Upper Basin. Since Yellowstone was set aside as a national park this pool has been signaled out as one of the important springs to see. This has been due to the beautiful emerald hue of the water. The coloration results from a combination of factors. Limpid springs that are above 164 degrees F. in temperature are blue in color. The color deepens with increased depth. If the temperature of a particular spring ranges from about 155 to 164 degrees, yellow algae line the crater. It is the combination of blue and yellow that is responsible for the green color. During recent years the temperature in Emerald Pool has dropped from an average of about 155 to about 150 degrees. The lower temperature has changed the color of the algae from yellow to orange-brown, resulting in a much less beautiful pool. There is abundant evidence that vandalism is partially responsible for the change in coloration.

Some of the other important springs in Black Sand Basin are Rainbow, Sunset Lake, Green, Black Sand Opal, Cliff and Spouter. Most of these springs are geysers. With the exception of Spouter, a nearly constant performer, all are cyclic and erupt at uncertain intervals. Black Sand Opal is one of the loveliest pools in the Park. To see or photograph it to best advantage it must be visited during the morning hours.

Castle Geyser

Since the discovery and naming of Castle, it has held a position of great interest. This has been due not only to its unusual eruptions, but to the fact that it possesses the largest and one of the most interesting structures of any geyser in the Park. "This geyser has the most imposing crater in the Upper Basin and was so named by Langford and Doane in 1870 because of its fancied resemblance to the ruins of a feudal castle; although, from most points of view it is more like the ruins of a tower or turret on the end of a platform, suggesting the form of a monitor iron-clad vessel." (Hayden, 1878, p. 204).

Castle's tower or cone is at the top of a very large mound which rises 40 feet above the river. At the base of the cone or turret, the circumference is about 120 feet, with a diameter of 20 feet at the top. The orifice is 2.3 x 2.7 feet and has been plumbed to a depth of 35 feet. The south side of the cone is very steep, being marked by a series of steps; it is also quite smooth due to frost spalling. The north side opens into the crater. The sinter here is fantastic in shape and of unusual beauty. Vandalism has destroyed much of the original loveliness.

CASTLE GEYSER in steam phase. Erupts about every 9 hours.

Early descriptions of Castle's eruptions indicate that not all observers saw the same pattern of action. Some of the eruptions described are without the concluding steam phase. The height given is also quite variable. It was early recognized that Castle had at least two distinct types of activity. "The points we have recorded prove that besides the eruptive action, which has a well-defined course of procedure, there is a state of constant activity, which is accompanied by spurts which reach 50 or even 60 feet, as seen by Doane and Langford. They, however, did not see a genuine eruption, in which the steam period is the most marked feature, and forms the peculiar action of the Castle." (Hayden, 1878, p. 207).

Early records of Castle's activity are very scanty. From about 1895 until 1920 interest in the hot springs by administrative officials seems to have gone into complete eclipse. Even the guide books of this period are verbatim reports of earlier issues. Scanty data of this period indicate that the time of Castle's eruption was uncertain; also that the nature of the activity was variable. There were periods of dormancy. During dormancy—that is dormancy of steam phase eruptions, water almost constantly splashed above the cone, with an occasional jet of 20 to 30 feet. An official report, dated 1927, states: "Today its normal activity is a steady steaming with jets of water thrown 20 to 30 feet every minute or two. Every four to eight weeks, it has an exceptional eruption during which water is thrown over a hundred feet for a few minutes followed by a tremendous steam period that lasts for several hours."

The above type of activity, with variations, characterized Castle for most of the following decade. However, there were periods,

lasting for weeks at a time, when Castle would be in what the writer termed a "sloppy stage"; which was characterized by continuous splashing of water above the rim of the crater.

By 1946, it was observed that Castle has a still different type of an eruption, briefly alluded to in early records; one which lasts from 2 to 4 minutes. The water is projected to a height of not less than 100 feet. These eruptions have no concluding steam stage, and are very spectacular. Still a different kind of an eruption was noted in 1949; one lasting only a minute or two with a height from 60 to 70 feet.

Great variations in eruptive behavior have characterized Castle during the greater part of its known history. About 1947 it entered an eruptive period, which, for frequency, regularity and adherence to type, is without precedent. Since the above date the continual splashing for days to months has not occurred. There have been few occasions when a non-steam phase eruption has been observed. From 1947 until the 1959 earthquake, the average eruption time was about every 15 hours. These eruptions were almost wholly of the steam phase type. If a 2 to 4 minute eruption occurred, which was infrequent, the following interval was about 8 hours.

The 1959 earthquake did not alter Castle's pre-quake pattern. However, it did greatly shorten the interval. For 3 weeks eruptions occurred about every 4 to 6 hours. All were accompanied by a steam period; the eruptions lasting 60 to 80 minutes. By 1960 it settled down on a pattern of play that has characterized it to date. The eruptions are highly predictable; they occur on the average about every 9 hours. Except on rare occasions, when a 2 minute eruption occurs, all are of the steam phase type.

Following an eruption of Castle, spray is continually jetted for about 2 hours. For the next few hours steam wells quietly from the crater. About 3 hours before an eruption, water periodically splashes above the cone. These splashes increase in forcefulness until one of the big surges lifts a massive column of water skyward. A great volume of water is discharged during the first few minutes. The eruption is characterized by almost continuous jetting, with occasional pauses of a few seconds, when the water again rockets up. The jets vary greatly in height; some of no more than 30 feet, with others near 80.

The water phase lasts about 15 minutes. At this time the jets become more steady, finally resulting in the steam stage of the eruption. During the early part of the steam stage the eruption is very impressive. Steam and spray issue under great pressure, accompanied by a deep roar. In reference to this stage of the eruption, the Earl of Dunraven wrote that it reminded him of "a gigantic boiling pot with a thunderstorm in its stomach." (1876, p. 267).

The history of Castle since 1870 is clear and definitive that it

has not followed a set pattern of play as has Old Faithful. To those who have known it only in recent time, the steam phase eruption is typical. Castle, however, has a well-proven versatility. Like Fountain, Giantess, Clepsydra and Steamboat, it is not stereotyped. It possesses a multiple personality, perhaps more so than any other geyser. Further recurrences of periods of great irregularity, and a shifting to some of its earlier patterns of play, can be expected. There is also a high degree of probability that in its juggling performance it yet has a new trick up its sleeve.

Crested Pool

Crested Pool is on the summit of the same mound as Castle, but on the north side. It is a large, circular spring, 21 x 22.7 feet, and has been plumbed to a depth of 42 feet. Most of the time the temperature is about 200 degrees F. The boiling point of water at this elevation is 199 degrees F., or 93 degrees C. Due to its depth the water is an intense blue, being a darker shade than Morning Glory. On rare occasions Crested Pool erupts with the water doming up about 6 feet.

Grand Complex

The history of Grand Geyser reveals that it belongs to that class of geysers which has shown great irregularity, with occasional periods of dormancy. The geysers along the Firehole River which show great irregularity, without any known exceptions, are connected subterraneously with other springs. The occasional shifting of the focus of thermal energy, called **"exchange of function"**, determines whether a particular geyser might be in an active or dormant cycle. Many springs are known to have underground connections with Grand. Most of them are geysers which have a marked influence upon its eruptive behavior. Some of the more important of these geysers are Turban, Vent, West Triplet and Rift.

Grand Geyser

Grand is located at the base of a hill of outcropping rhyolite across the river from Castle. Among the many geysers in Yellowstone Park that have intrigued and captivated Park visitors few, if any, have surpassed Grand. It made its modern debut on August 5, 1871. The spectacle was so impressive that the adjective "grand" was at once chosen as a name by the Hayden Party. "We camped the evening of August 5th in the middle of the Upper Geyser Basin in the midst of some of the grandest geysers in the world. Colonel Barlow and Captain Heap, of the United States Engineers were camped on the opposite side of the Firehole. Soon after reaching camp a tremendous rumbling was heard, shaking the ground in every direction, and soon a column of steam burst forth from a

crater. Following the steam by a succession of impulses, a column of water, apparently six feet in diameter, rose to a height of 200 feet. . . We gave it the name Grand Geyser for its power seemed greater than any other of which we obtained any knowledge in the valley." (1872, p. 116).

Unlike Castle, Giant, Beehive or Old Faithful, Grand has no raised cone. It rests on a gently sloping expanse of sinter. Its crater is a shallow basin, 52 feet in diameter. Water over the greater section of the bowl is less than a foot deep, except directly over the orifice, which is 25 feet deep. The wide basin slopes gradually to the orifice, about which are "large cushion-like masses of geyserite".

There is nothing about the crater of Grand to suggest the inherent power and beauty of an eruption. The crater of Turban, which is separated from Grand by a narrow bridge of sinter, is much more suggestive of major geyser potential. It is oblong in shape, being about 15 x 25 feet; its greatest depth is 10 feet, with a massive shoulder of geyserite surrounding the crater. This shoulder rises 14 inches above the level of Grand when the latter is full and overflowing. The name Turban was suggested from the shape of a number of protuberances in the crater. Vent Geyser is a mere slit in the geyserite on the north edge of Turban's cone. The craters of Turban and Vent are described in connection with Grand's because of the existence of a close interfunctional relationship.

An eruption of Grand occurs when its crater is full and overflowing. Following an eruption it takes from 3 to 8 hours to again reach the overflow stage; the length of time being dependent upon the time Turban and Vent continue their concerted play following an eruption of Grand.

When Grand reaches the overflow stage it overflows periodically. Its periods of overflow are related to Turban's eruptions. From the instant water starts to rise in Turban's bowl—a certain evidence of pending activity—the water starts to drop in Grand. This drop is about 1 inch; enough to stop all overflow for about 8 minutes. Grand erupts only at the time of one of Turban's active periods. If Turban starts erupting without an immediate follow. up of Grand, it will certainly be another, perhaps many, of Turban's periods before Grand erupts.

The first premonitory signs of an eruption of Grand are an ebb in Turban and a slight increase in the overflow of Grand. Usually within a matter of 10 to 20 seconds following this evident shift in pressure, a slight pulsing is noted in Grand, sending waves shoreward over the large collecting basin.*

The pulsing as well as the waves increase in forcefulness,

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* On rare occasions this pulsing will cease, resulting in Turban's activity with no consequent eruption of Grand.

sometimes for several minutes, when suddenly there is a doming of water over the orifice, followed by a sudden explosion and rocketing of water.

During an active phase Grand has a number of independent bursts, or eruptions. The initial burst is quite variable, not only in the manner of ejection, but also in height and duration. As a general rule the initial explosion lasts from 1 to 2 minutes, but at times as long as 12 minutes. If the duration of this phase of the eruption goes much beyond 2 minutes, it is characterized by successive rockets of water, from 50 to 100 feet in height. Successive rockets as described above will at times occur during the second burst.

Following each burst the water column will drop with a suddenness that almost equals its explosive ejection. The water then rushes back into the crater, but within seconds there is doming and another massive column is shot into the air.

The number of separate eruptions during an active phase varies anywhere from 6 for a minimum, with 45 the most observed to date. For the great majority of eruptions the number of separate bursts varied between 8 and 12, with the active phase lasting from 12 to 20 minutes. When 30 or more bursts occur, the eruption usually lasts for more than an hour.

As a general rule the second, third, fourth and fifth bursts are the most massive and play to a greater height. Instead of a uniform stream of water, as with Old Faithful, many independent jets rocket through the massive column. Some of these jets occasionally reach 200 feet in height. At the conclusion of the last eruption the crater empties and much of the water drains back into the well. Since the 1959 earthquake, Grand has had a major burst about 20 minutes following the emptying of the crater. This behavior is not without precedent.

An eruption of Grand sets up a chain action in Turban, Vent, Triplets and Rift. Turban and Grand usually start erupting within a few seconds of each other. This action is a precursor to action of Vent. Vent's eruption, about 30 feet high, may start during the latter part of Grand's first burst, but more frequently during the second. Turban, which, following its 17 minute intervals, has been splashing 3 to 5 feet for about 4 minutes, now surges violently 6 to 10 feet high. The concerted action of Turban and Vent sometimes ceases with the last eruption of Grand, with craters emptying immediately. Again it may continue for an hour before emptying occurs. After about half an hour of rest both Turban and Vent resume eruptive activity. During the eruptive phase, cessation and resumption of activity occur two or more times before Vent ceases erupting, Turban refills and gets back on its solo, 17 minute interval. Near the beginning of an eruption of Grand, West Triplet will become active. From 30 minutes to an hour following Grand, Rift begins erupting. Its action sometimes lasts for several hours.

Since the 1959 earthquake it has been observed for the first time that following pressure buildup in the Grand complex, Vent will begin erupting with all companion geysers quiescent. Should the visitor be fortunate enough to arrive on the scene at such time, he may be assured that an eruption of Grand is pending. From 1 to 2 hours following the start of Vent, Grand erupts.

Early guide books indicate quite a wide variation in the length of Grand's intervals; the minimum being about 8 hours, with days for a maximum. It is quite certain that but a small part of the eruptions were recorded, due to infrequent and spasmodic observations. From about 1920 to the present, records of geyser activity have become increasingly detailed and complete. These records reveal that Grand's intervals show wide variation. Some seasons the average was nearly 8 hours, during others over 40, with two periods of dormancy. Beginning in 1947 Grand began showing increasing activity which persisted until the 1959 earthquake. During this period the average interval varied between 8 and 12 hours. There was sufficient regularity to make eruption time relatively predictable.

Grand, like hundreds of thermal springs in the Firehole Geyser Basins, was induced into eruptive activity by the Hebgen Lake Earthquake of 1959. Following this eruption all geysers in the Grand Complex became dormant, and it was 6 months before Grand again erupted. From this date to the present there has been a slow increase in the frequency of its eruptions; which as yet are not predictable. However, Grand has undoubtedly been subjected to major earthquakes before 1959. This consideration, together with the growing frequency of eruptions, plus the record of its past behavior, hold rich promise for recurring periods of frequent and predictable eruptive activity.

Sawmill Geyser

This small but interesting geyser is located about 100 yards south of Grand. It was named in 1871 by the Hayden Survey. The name Sawmill was suggested because of the circular motion of the water in the bowl during an eruption.

Sawmill is a fountain-type geyser. It has a funnel-shaped crater, which is about 7 by 8 feet at the top of the bowl. The outside diameter of the sinter deposit is 42 feet. In this deposit on the south side of the vent there is a small geyser of infrequent and uncertain performance.

During most of Sawmill's known history it has been in an active phase about half of the time; the intervals as well as the eruptions being about 3 hours in duration. However, it has shown considerable variation from this pattern; the eruptions at times lasting only from 45 minutes to an hour. This variation in eruptive behavior results from its underground connections with Tardy,

a small geyser 30 feet to the southeast. There is a decided sympathetic relationship between these two geysers. During 1963 the almost constant activity of Tardy brought about near dormancy of Sawmill.

An eruption of Sawmill is characterized by rapid pulsations or jets, there being 40 to 50 per minute. The explosions break through the overflowing bowl and are ejected to heights ranging between 5 and 30 feet. The sudden expulsion of the jet breaks the water into innumerable droplets which, in the sunshine, look like glittering crystals. An eruption of 3 hours duration discharges about 4 times as much water as an eruption of Old Faithful.

Other small, named geysers located near Sawmill are Penta, Spasmodic and Bulger.

Beauty and Chromatic Pools

Beauty and Chromatic are located about 30 yards north of Grand. They have an interesting interfunctional relationship and there is an alternating pattern in their activity. For periods ranging from a few weeks to about 2 years, water will flow from one spring and then from the other. Water always stands near the rims of the craters. During the overflow cycle, the water only stands an inch higher than when in ebb. With the ebb and flow, there is a shift of about 10 degrees in temperature; the flowing spring being the hotter.

Both springs owe their attractiveness to algae which line their craters and overflow channels. Beauty is the largest, being 57 x 65 feet; it is also the most interesting. For the most part the basin is shallow, sloping gently toward the vent. This has resulted in a concentric color pattern, ranging from yellow to red. It gives the pool a beautiful rainbow-like effect.

Beehive Geyser

Beehive is located on Geyser Hill, in the hot-spring group which can be seen directly across the river from Old Faithful. It is on the lower level of Geyser Hill, and is 182 feet from the river. It can be distinguished at once by its dome-like cone, which looks very much like the old-fashioned beehive. It was named Beehive by the Washburn party in 1870 because of the shape of the cone.

The cone rests on an older, badly eroded sinter sheet. It is 3 feet 6 inches high, with a diameter of 4 feet at the top. The circumference at the base is 21 feet. The orifice at the top is 2 x 3 feet, but constricts to a diameter of about 8 inches near the base of the cone. It has been plumbed to a depth of 23 feet. Unlike a number of near-vertical cones, badly spalled by the frost, Beehive's is beautifully covered with beady silica with a pearly luster. The appearance of the cone has not noticeably changed since 1870. Mod-

ern photographs look like reproductions of pictures made during the 1870's. In general the same holds true for other geysers.

Beehive's history is one of great irregularity. Observations made in the 1870's by scientific parties indicate periods of infrequent activity, and other periods when an eruption occurred about once per day, with some intervals as short as 8 hours. Prior to the establishment of the National Park Service in 1916, the first detailed record of Beehive's activity, covering several weeks of observation, is found in Captain George S. Anderson's report for 1896. To determine whether or not "any geyser except Old Faithful showed regularity", he had the guards keep records of a few of the major geysers. These records were kept for July, August and September, 1895, and for June and July, 1896. The number of eruptions of Beehive per month was: 1895, July-16, August-19, September-20; 1896, June-3, July-7 This record is of interest, not only because it stands isolated in a vacuum of geyser interest of long duration; it also is indicative of the great irregularity which marks Beehive's known history.

From 1896 until 1920 only the time of a single eruption of Beehive is a matter of record. Geyser data were either not kept, or they were lost. **Haynes Guide**, 1912, gives Beehive's intervals as ranging "from 12 to 40 days". Geyser records of the 1920's reveal that it seldom erupted. The most eruptions recorded in any one season were 17 in 1929. From 1930 through 1946, there is a record of only 17 eruptions. In this period, during the summer months, Beehive was under close surveillance. The number of eruptions reported is certain evidence they were few and far between.

During the winter of 1946-47 there was a marked rejuvenation of geyser activity in the Upper and Lower Basins. Beehive shared in this increased energy output. From 1947 through 1960 there is a record of 835 eruptions*, as against 142 for the period from 1870 through 1946. While the paucity of recorded eruptions from 1870 to 1947, as compared to the recent period, is due primarily to lack of data, the evidence is sufficiently complete to denote great irregularity and periods of near dormancy.

One of the causes of Beehive's great irregularity results from underground connections with other thermal springs. **Haynes Guide** states: "There is undoubtedly some relation between this geyser (Beehive) and the Giantess, a hundred yards higher up on Geyser Hill, because invariably after eruptions of Giantess, the Beehive plays two, three and sometimes four times, at intervals of 8 to 12 hours, and occasionally, but rarely once **before** the Giantess, but at no other times." (1912, p. 73). An official 1927 report states: "Without doubt the greatest loss to the Park in recent years is the almost complete inactivity of Beehive Geyser...

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* Due to near absence of winter data it must be appreciated that Beehive erupted many more times than 835 during this period.

In the 'old days' Beehive played alone frequently but most often only a few hours after the Giantess." In an official report for 1928, Superintendent Horace M. Albright states: "Beehive and Giantess Geysers have always been reported to erupt together but observations during the past few years do not bear out this theory." The author is aware of but two eruptions of Giantess in recent years that were followed by sympathetic eruptions of Beehive. However, data are abundant that most of the springs on Geyser Hill are connected subterraneously.

Frequent references are found in early literature to Beehive's Indicator. This is a small vent located 10 feet east of Beehive. An eruption of the Indicator was a precursor to an eruption of Beehive. Following the creation of the National Park Service, there is no reference to any eruptive activity of the Indicator until 1951. From then through 1953, which was a period of marked activity of Beehive, its eruptions were invariably preceded by the Indicator. The eruption was 3 to 6 feet high and would start 30 to 45 minutes before Beehive. Since 1953, the Indicator has been observed very infrequently. Presently its vent is almost completely choked due to vandalism.

Since Beehive was observed and named by the Washburn party in 1870, it has held high priority on the list of all who have been interested in seeing Yellowstone's major geysers. During its quiet phase, water frequently splashes above the rim of the crater. When an eruption is pending the surges are higher and more frequent. The eruption starts by one of the heavy surges growing in volume, and then suddenly rocketing skyward. As the eruption proceeds, the water column continues to grow in height for about the first 60 to 90 seconds. Maximum height is maintained for about 1 minute, when the column slowly descends. During the concluding stage, there is a marked steam phase. The duration of an eruption is variable, ranging between 5 and 8 minutes.

A hastily improvised method of measurement used by the Washburn party in 1870 showed a height of 219 feet for Beehive. No measurements made since have reached that figure. A few triangulation measurements show heights varying between about 150 and 200 feet. The average eruption height would seem to be near 150 feet. Due to the nature of the water column a strong wind will lower its heights by many feet.

An eruption of Beehive is very impressive, especially if the viewer is close by. During the early stage of the eruption, there is heavy discharge, and, due to the small aperture and great head of steam, the water is ejected under terrific pressure. For many, the roaring during the steam phase is an intimidating experience. The great volume of steam breaks the column into innumerable droplets and spray, which are wafted away by air currents, forming a beautiful rainbow.

Plume Geyser

Plume is located about 150 feet due east of Beehive. Its crater, 1.5 x 1.7 feet, is a mere rift in an older sinter sheet. As a geyser it seems to be of comparatively recent origin. During the quiet phase, there is no boiling and the crater is nearly empty, affording no hint that it might be a geyser. The eruption starts suddenly and almost immediately attains maximum height, which varies between 25 and 35 feet. The water is projected at an angle, about 15 degrees from vertical.

Before the 1959 earthquake, Plume erupted about every 54 to 70 minutes, the eruptions lasting for 4 minutes. Following the quake, there was a dormant period of a few weeks and then rejuvenation. Since rejuvenation the intervals have progressively been getting shorter. During the 1963 season, they varied between 23 and 25 minutes, with the duration about 2 minutes.

The history of Plume reveals that it is cyclic, with long dormant periods followed by long active ones. The last active cycle began about 1941.

Giantess Geyser

Giantess is located at the top of a large mound on the east side of Geyser Hill. On this same mound are two other important springs: Teakettle and Vault Geyser. Infant Geyser is 100 feet east. These 3 springs show a marked sympathy to an eruption of Giantess.

The crater of Giantess is 22.3 x 34 feet. It has been plumbed to a depth of 72 feet. The visible portion of the crater is bowl shaped and about 30 feet deep. A comparatively small orifice, the source of the thermal energy, opens into the bowl on the west side. The geyserite surrounding the crater is largely lacking in ornamentation, so characteristic of most of the geysers. However, most of the crater is ringed with a beautiful fringe of scalloped sinter. This scalloped border apparently has been growing in height, as is indicated by the laminated geyserite surrounding the crater and projecting over the basin. During the quiet phase (its usual state) the water is of a deep-bluish tint.

Giantess was named by the Washburn party in 1870. During its short stay this party was fortunate to witness an eruption. All were "wild with enthusiasm". N. P. Langford wrote: "We unhesitatingly agreed that this was the grandest wonder of our trip." They reported the heights of some of the rocketing jets as being not less than 250 feet. Lieutenant Doane was even more enthusiastic than Langford.

The glowing descriptions of the power and magnificence of Giantess placed it high on the agenda of geysers to be seen by succeeding parties. Eruptions which were observed by later parties

GIANTESS GEYSER — Eruption intervals vary between about 7 days and months.

were on the whole quite disappointing. They did not measure up to expectation. This led one observer to write: "It refused to give us one of its grandest displays. . . I think its glory is departing." (Stanley, 1878, p. 103). The fact that some of the parties following the Washburn Expedition did not see an eruption of Giantess which measured up to first descriptions is largely due to the length and varied character of the eruptions; also that the first expedition might have seen one of those unusually powerful displays which at times characterize this geyser. The enthusiasm which results from first impressions must also be given due consideration.

Giantess is a typical fountain-type geyser. Its eruptions do not progress steadily until the end. The active phase of many hours duration, is made up of many separate periods of eruptive activity. The magnitude of the separate periods shows wide variation. To see it during but one of its separate periods and not witness the entire eruption, would lead to very different impressions of its power. This in great measure accounts for early differences in description.

The length of the active phase shows wide variation, ranging between about 12 and 36 hours. An eruption which was stimulated by the 1959 earthquake lasted for over 100 hours. Whether the duration of the eruption is near minimum or maximum depends upon the type of the eruption. The water phase of some eruptions is followed by a steam phase. Steam phase eruptions are much shorter than those without.

During the quiet phase Giantess overflows steadily, discharging about 25 gallons per minute. There are occasional boiling periods. The initial throes of an eruption are characterized by surging and greatly increased overflow. This is accompanied by audible detonations at depth which jar surrounding formations. The water then begins surging 10 to 15 feet high, with an occasional surge of about 30 feet. The surging lasts from 15 to 20 minutes, during which there is heavy overflow. Following the period of surging, the water drops below the rim of the crater to be followed in a few more minutes by more surging. Sometimes the second period of surging does not occur. In either case, the lowering of the water in the crater is followed by rocketing jets of water which come in

rapid succession. These jets vary greatly in height. Some are no more than 20 or 30 feet while others are much higher. After about 5 minutes, this stage of the eruption ceases.

During an active phase, the 5 minute periods of eruptive activity recur about every 15 to 30 minutes during the first few hours. The intervals gradually increase to about an hour. Sometimes the highest rockets occur following the initial jetting. At other times they come much later. The maximum height of the jets for different eruptions varies. The range being between about 100 and 200 feet. If the eruption is steam phase in type, after the initial jetting, steam under great pressure issues from the crater. With diminishing force, the steam period lasts for about 11 or 12 hours. The roar of the outrushing steam in the early stages is deafening when standing near the crater.

During an eruption of Giantess the water in the craters of Teakettle and Vault gradually lowers. At the conclusion all craters are empty and all refill simultaneously, which takes about 3 days before the overflow stage of Giantess is reached. During an active phase of Giantess, Infant geyser boils steadily. Some of the infrequent and more powerful eruptions of Giantess have noticeable effects on many of the springs on Geyser Hill.

Early records relating to the frequency of an eruption of Giantess are very indefinite. They indicate long periods of inactivity, while at other times it was reported to erupt "about every 14 days". Observations made in 1895 and 1896 show intervals ranging between 4 and 12 days. No more such short intervals were reported until 1920. However, records during succeeding years in the 1920's are clear in indicating that eruptions occurred infrequently, months often intervening between them. In 1929, 7 eruptions were reported. From this date to the present, with few exceptions, Giantess has erupted only 1 or 2 times each year.

The great irregularity of Giantess would seem to result primarily from its underground connections with numerous other springs. Many of these springs are periodically active as geysers. If there is a general decline in activity over that which characterized it during some earlier period, it could in part have resulted from the steadily growing border about the crater. Increased water level results in increased hydrostatic pressure, necessitating more heat to effect an eruption.

Giantess, like the great majority of thermal springs in the Firehole Geyser Basins, has been the recipient of a great amount of vandalism on the part of Park visitors. As an indication of what was done earlier, a reference or two will suffice: "After we had become somewhat accustomed to the noise of the eruption, and the awe inspired by the vast outburst had subsided, we experimented upon the violence with which the vapor was ejected by throwing into the crater trunks of trees and logs, and other objects which could be found near at hand." (Ludlow, 1876, p. 121). "Near at hand" were many rhyolite boulders and much fragmental sinter.

Again: "As the crisis approaches the water sinks in the basin, and when stones or other objects are thrown into it, it boils furiously, foaming up, and sometimes running over the edge." (Haupt, 1883, p. 91). With guide books making such novel suggestions on ways of disturbing the tranquility of Giantess, it would seem that many Park visitors would become experimenters. Descendants of these early visitors over the years, in ever increasing numbers, have been entering the geyser basins.

There is a high degree of probability that the great amount of vandalism the hot springs have been subjected to since discovery has had some influence upon their natural behavior. In the case of some springs these influences are marked and will become greater.

Lion Complex

There are four principal geysers in this complex. The three closest together were called the Trinity by the Hayden Survey. The largest of these three was named Niobe Geyser. The geyser not then named was later called Little Cub, while the other two came to be known as Lioness and Big Cub. Niobe was later changed to Lion by Superintendent Norris, which name it presently bears.

This interesting group of geysers is located on the northwest side of Geyser Hill. The four cones rest on the flattened summit of a large geyserite dome. They are much younger than the dome. This is indicated not only by their position, but the water from eruptions has produced deep erosion channels in the older sinter. That there was a period of quiescence before the growth of the present cones is indicated by partially exposed, silicified tree sections.

The four geysers in this complex are connected underground. An active cycle of Lioness and Big Cub brings about dormancy of Lion and vice versa. Following an eruption of Lioness and Big Cub, and only then, Little Cub goes into a marked steam stage.

Since the time of the Hayden party there have been but few known occasions when Lioness and Big Cub were in an active cycle. They have been observed to erupt simultaneously, also independently, but more frequently an eruption of either one will stimulate follow-up activity in the other. The duration of the eruptions is about 3 to 6 minutes. Big Cub plays about 40 feet high; Lioness from 20 to 30. Little Cub is the most active one in the group. Its intervals vary between 1 and 4 hours; the height is from 10 to 15 feet, and the eruptions last from 15 to 20 minutes. During the quiet phase there is occasional jetting of water.

Lion Geyser

Compared with other geysers in this complex, Lion has much the largest cone, indicating a greater degree of boiling and splash-

ing activity over the years. The massive cone has a circumference of 46 feet at the base; a diameter of 5 feet at the top and rises 4 feet and 6 inches above the mound. The orifice is 1.2 x 2 feet and has been measured to a depth of 72 feet. Lioness has been plumbed to a depth of 19 feet; Big Cub 22 and Little Cub 5½ feet.

Until the 1920's, records relating to Lion are largely lacking. Observations made during this period indicate that it "erupted several times each day". It was not until the early 1940's that the true nature of its behavior was noted.

While Lion is a cone-type geyser so far as structure and function are concerned, it has one habit that is characteristic of fountain geysers; that is, when in an active phase, it has a series of eruptions. During an active phase, major eruptive activity occurs about every 1 to 3 hours. At times no more than 2 eruptions occur during an active phase. If the phase lasts for 24 hours or more there are a dozen or more eruptions. Until 1959 the active phase occurred every 2 to 3 days, lasting from about 4 to 36 hours.

Except for the initial eruption the remaining ones in a series are preceded by sudden gushes of steam, accompanied by a deep roaring sound—hence the name Lion. There is occasional roaring between eruptions. The height varies between about 40 and 60 feet. Usually the initial eruption is the highest. The duration of the water phase is from 4 to 5 minutes, followed by a steam period of about equal length.

Old Faithful*

Old Faithful was named in 1870 by members of the Washburn Expedition. During their short stay in the Upper Basin they were fortunate in seeing many of the larger geysers erupt, and those were named. It was observed that one of the big geysers erupted with remarkable frequency and a degree of regularity. Despite the fact that the observations covered but a day and a half, the name Old Faithful was given to this geyser. The name proved to be a most fortunate choice. Only one other major geyser in the Park (Riverside) has approached Old Faithful's record for regularity and consistency of performance. However, it has erupted about 7 times more frequently during the post-discovery period than has Riverside.

There is a more complete record of Old Faithful's eruptive behavior than of any other geyser. Since it was named in 1870 it has continued to erupt on essentially the same pattern, the eruptions recurring at **nearly** hourly intervals. Contrary to popular opinion, Old Faithful never did erupt on the hour except by coinci-

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* For a more complete and detailed account of Old Faithful see **The Story of Old Faithful.** This booklet can be obtained at the visitor centers in the Park, or can be purchased by mail from the Yellowstone Park Library and Museum Association, Yellowstone National Park, Wyoming.

dence. The average time is slightly over an hour. Records show that the overall average is about 65 minutes; the range being between 61 and 67 minutes.

Practically every factor relating to Old Faithful is a variable one. Not only do the eruption intervals vary (extremes noted to date are 33 and 95 minutes), but the duration of the eruption as well as the height are also variable. The average height is about 130 feet; the extremes being about 100 and 184 feet. The duration ranges from slightly less than 2 minutes to about 5 minutes. The length of the active period governs the length of the interval. An interval which follows an eruption of near minimum duration is always under average. Short intervals are followed by over-average ones; 4 to 5 minute eruptions are always followed by average or over-average intervals.

There is a widespread impression among many Park visitors that Old Faithful is measurably slowing down. Records do not support this belief. This misconception results primarily from faulty observations, absence of data, and unawareness that there are wide variations in eruptive behavior. The 1959 earthquake resulted in a slight increase in seasonal average, but the gain did not bring it up to some of the early records. Following a few months' jump in average the trend has been toward shorter intervals. The 1963 average, 65 minutes, was essentially the same as the overall average.

While Old Faithful is classed as a "regular" geyser, the time of an eruption is unknown. In predicting eruption time, as has been indicated, knowledge of the duration of the preceding eruption is of primary importance; also the seasonal pattern of behavior. In the absence of these data the season's average is the figure used. It is merely coincidence if it erupts at the time predicted. In general most of the eruptions occur within 5 to 10 minutes of the average time.

Following an eruption of Old Faithful the steam, with occasional puffs, wells quietly from the cone. The first indication that an eruption is pending is a splash of water above the rim of the crater. This splash is generally followed by succeeding splashes or surges, sometimes as many as 20 before the eruption occurs. Infrequently the eruption will start with the first surge. This happens only at the time of some of the much under-average intervals.

It takes from 15 to 20 seconds for an eruption to reach maximum height; which is attained following 2 or 3 heavy surges, each of greater force. Maximum height is maintained for about 20 seconds, usually less, and is followed by rapid lowering of the water column. The average eruption discharges about 11,000 gallons.

With proper lighting and position with relation to the wind, Old Faithful affords a sublime spectacle. This, coupled with its remarkable frequency, which is not even closely approached by any other major geyser, makes it one of the wonders of the world.

Lone Star Geyser

Lone Star is the only large geyser on the Firehole drainage which is farther up the river than Old Faithful, the distance being about 4 miles. Its isolated position with relation to the geysers of the Upper Basin is responsible for the name. Its large chimney-like cone is at the base of a moraine, indicating it might represent hydrothermal activity which emerged following the burial of pre-glacial hot springs.

It has one of the largest and most interesting cones of any geyser in the Park. Its circumference near the base is 50 feet, and its height is 11½ feet. The apex of the cone is of considerable interest in that in addition to the main vent, there are numerous small apertures from which water is ejected during an eruption. The sides of the cone have been subjected to frost spalling, nevertheless they are elaborately ornamented with pearly beads of sinter, varying in color from pink to silver gray.

Lone Star's eruptive behavior indicates that it might be an isolated unit: that is, it does not seem to be influenced in its activity by underground connections with other thermal springs. This has resulted in a uniform pattern of behavior and regularity over the years. Descriptions of eruptions today, and the frequency with which they occur, sound very much like those of the first observations which were made in 1872 and 1873.

During the quiet phase there is nearly constant splashing of water above the crater rim. This is responsible for the greatly exaggerated vertical growth of the cone. An eruption begins following one of many heavy surges. Water is ejected to a height of about 25 feet, with continuous jetting lasting from 3 to 5 minutes. The eruption then ceases very suddenly, but this is merely a prelude to the main eruption. After a pause of from 15 to 25 minutes the second phase of the eruption begins, and lasts from 25 minutes to half an hour. The column of water is small, but it is ejected under great pressure. Maximum height, 30 to 40 feet, is attained near the middle of the eruption. The latter part of the activity is characterized by a marked steam phase, resembling Castle's. Eruptions occur at about 3 hour intervals.

Table of Named Hot Springs in the Upper Geyser Basin Which Have Shown Geyser Activity

	Height	Duration	Interval
Anemone Geyser	6 ft.	Min. to hrs.	Frequent
Arrowhead Spring	8 ft.	5 min.	Rare
Artemisia Geyser	30 ft.	13-15 min.	24-30 hrs.
Atomizer Geyser	20 ft.	1-10 min.	Daily
Aurum	10 ft.	2-4 min.	Cyclic
Avoca Spring	3-12 ft.	Seconds	60 sec.
Baby Daisy Geyser	20-30 ft.	3-4 min.	1-2 hrs.*

	Height	Duration	Interval
Bank Geyser	2 ft.	10 sec.	45-60 sec.
Beach Geyser	3 ft.	1-2 min.	Cyclic
Beehive Geyser	100-150 ft.	5-8 min.	2-5 days*
Bell Geyser	10 ft.	1-2 min.	Rare
Bench Geyser	3-6 ft.	Seconds	1-3 min.*
Big Cub Geyser	30 ft.	4-8 min.	Seldom*
Bijou Geyser	8-20 ft.	Near Steady	Near Steady
Biscuit Basin Geyser	75 ft.	4-5 min.	Infrequent
Black Pearl Geyser	4-8 ft.	Seconds	Frequent
Black Opal Spring	10 ft.	1-2 min.	Rare
Black Sand Pool	Boiling	1 min.	Frequent
Box Spring	4-5 ft.	2 min.	Rare
Brilliant Pool	10-20 ft.	1 min.	Rare
Calthos Geyser	4-20 ft.	1 min.	Rare
Cascade Geyser	15-20 ft.	2-3 min.	1-2 hrs.*
Castle Geyser	63-100 ft.	45-60 min.	8-10 hrs.
Catfish Geyser	10-35 ft.	2-20 min.	Frequent*
Cauliflower Geyser	Boiling	1-2 min.	60-70 min.
Chinaman Spring	20-40 ft.	2 min.	Rare
Chain Lake Geyser	10-15 ft.	2-4 min.	Rare
Churn Geyser	Boiling	Hours	Cyclic
Cliff Geyser	20-35 ft.	2-3 hrs.	12-15 hrs.*
Comet Geyser	4-6 ft.	1 min.	4 min.
Coral Geyser	6-10 ft.	5-8 min.	8-15 min.
Crested Pool	3-4 ft.	1-2 min.	Rare
Cucumber Spring	12-18 in.	Near Steady	Near Steady
Cyclops Spring	10-15 ft.	Undetermined	Rare
Daisy Geyser	75 ft.	3 min.	1½-3 hrs.*
Daisy's Thief	10-15 ft.	1-3 hrs.	Infrequent
Depression Geyser	6-8 ft.	2-3 min.	1-3 hrs.*
Dome Geyser	6-20 ft.	3-4 min.	Rare
Doublet Pool	Boiling	3 min.	Rare
Ear Spring	3 ft.	1-2 min.	Rare
Economic Geyser	10-20 ft.	Seconds	1-3 hrs.*
Economic, East	30-40 ft.	2-3 min.	1-3 hrs.*
Fan Geyser	100-125 ft.	13-15 min.	Infrequent
Fumarole Geyser	8-10 ft.	2-3 min.	45-60 min.*
Giant Geyser	180-225 ft.	1-1½ hrs.	2-14 days*
Giantess Geyser	75-200 ft.	12-36 hrs.	Infrequent
Grand Geyser	160-180 ft.	15 min. to 1½ hrs	8 hrs. to days
Green Spring	10-20 ft.	4-5 min.	3-4 hrs.*
Grotto Geyser	3-40 ft.	1-2 hrs.	1-12 hrs.
Hillside Geyser	6-20 ft.	3-4 min.	3-4 hrs.*
Iron Spring	3-4 ft.	Unrecorded	Rare
Jewel Geyser	12-22 ft.	1-1½ min.	5-6 min.
Link Geyser	4-75 ft.	15 min.	3-4 hrs.*
Lion Geyser	50-60 ft.	4 min.	1-2 hrs.*
Lioness Geyser	20-40 ft.	5-10 min.	Infrequent
Little Brother	15-25 ft.	4-6 min.	15-20 min.*

	Height	Duration	Interval
Little Cub Geyser	3-10 ft.	17 min.	1-2 hrs.
Little Squirt	3-6 ft.	Days	Days
Lone Star Geyser	20-30 ft.	25-30 min.	3 hrs.
Mastiff Geyser	4-100 ft.	Variable	Infrequent
Model Geyser	3-4 ft.	2-3 min.	1-2 hrs.*
Morning Glory Pool	30-40 ft.	Unrecorded	Rare
Mortar Geyser	30-40 ft.	13-15 min.	Infrequent
Mustard Spring	2-4 ft.	1-2 min.	5-8 min.
Myriad Geyser	100 ft.	4-5 min.	Rare
North Geyser	12-15 ft.	6-8 min.	1-2 hrs.*
North Goggle Spring	10-12 ft.	1-2 min.	Infrequent
Oblong Geyser	20-40 ft.	6-9 min.	3-8 hrs.
Old Faithful	100-184 ft.	2-5 min.	33-95 min.
Old Tardy Geyser	10-12 ft.	10-15 min.	Unrecorded
Orange Spring Geyser	3-4 ft.	4-6 min.	5-6 hrs.*
Pear Geyser	12-15 ft.	2-3 min.	Rare
Penta Geyser	20-25 ft.	30-45 min.	Infrequent
Plume Geyser	30-35 ft.	1-4 min.	23-70 min.
Pump Geyser	2-3 ft.	Steady	Steady
Rainbow Pool	20-100 ft.	6-8 min.	Rare
Radiator Geyser	8-10 ft.	4-5 min.	Rare
Rift Geyser	3-4 ft.	2-4 hrs.	8 hrs. to days
Riverside Geyser	75 ft.	20 min.	6-9 hrs.
Rocket Geyser	6-30 ft.	3-6 min.	1-12 hrs.
Roof Geyser	3 ft.	Seconds	5 min.
Round Spring	Boiling	Hours	Infrequent
Sapphire Pool	4-150 ft.	2-8 min.	15 min. to 2 hrs.
Sawmill Geyser	17-35 ft.	1-3 hrs.	1-3 hrs.*
Sentinel Geyser	20-30 ft.	Unrecorded	Rare
Shell Geyser	2-3 ft.	4-5 min.	2-4 hrs.
Scissors Spring	3 ft.	Unrecorded	Rare
Scalloped Spring	6-8 ft.	Unrecorded	Rare
Solitary Geyser	20-25 ft.	2 min.	2-6 min.
Spa Geyser	35-40 ft.	2 min.	Infrequent
Spanker Geyser	4-6 ft.	Steady	Steady
Spasmodic Geyser	3-20 ft.	20-40 min.	Daily
Splendid Geyser	100-164 ft.	2-10 min.	Hours to days*
Sponge Geyser	4-6 in.	Seconds	1 min.
Spouter Geyser	4-7 ft.	15-20 hrs.	Daily
Sprinkler Geyser	4-6 ft.	15-20 min.	Frequent
Sunset Lake	3-8 ft.	1 min.	Frequent
Surge Geyser	5-6 ft.	Seconds	4-6 min.
Surprise Geyser	65 ft.	17-60 min.	6-12 hrs.*
Tardy Geyser	6-10 ft.	1 to several hrs.	1 to several hrs.
Terra Cotta Spring	5-6 ft.	4-5 min.	2-3 hrs.*
Three Sisters N. Vent	3-4 ft.	1 min.	4-6 min.
Three Sisters E. Vent	15-20 ft.	3 min.	35-50 min.*
Three Sisters S. Vent	6 ft.	Unrecorded	Rare
Tilt Geyser	6-8 ft.	2-3 min.	1-2 hrs.*
Trail Geyser	40-50 ft.	2-3 min.	3-4 hrs.*
Trail Geyser, West	6-8 ft.	2-3 min.	3-4 hrs.*

	Height	Duration	Interval
Triplets, West	4-6 ft.	2-10 min.	1-2 hrs.*
Triplets, East	20-25 ft.	2-3 min.	1-2 hrs.*
Turban Geyser	5-10 ft.	3-60 min.	15-25 min.
Wave Spring	Boiling	Unrecorded	Rare
Whistle Geyser	30-40 ft.	3 hrs.	Infrequent
Witches Cauldron	3-4 ft.	Unrecorded	Infrequent
Vault Geyser	10-15 ft.	4-5 min.	1 hr.*
Vent Geyser	20-30 ft.	15-60 min.	8 hrs. to days

*Sometimes inactive for long periods.

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